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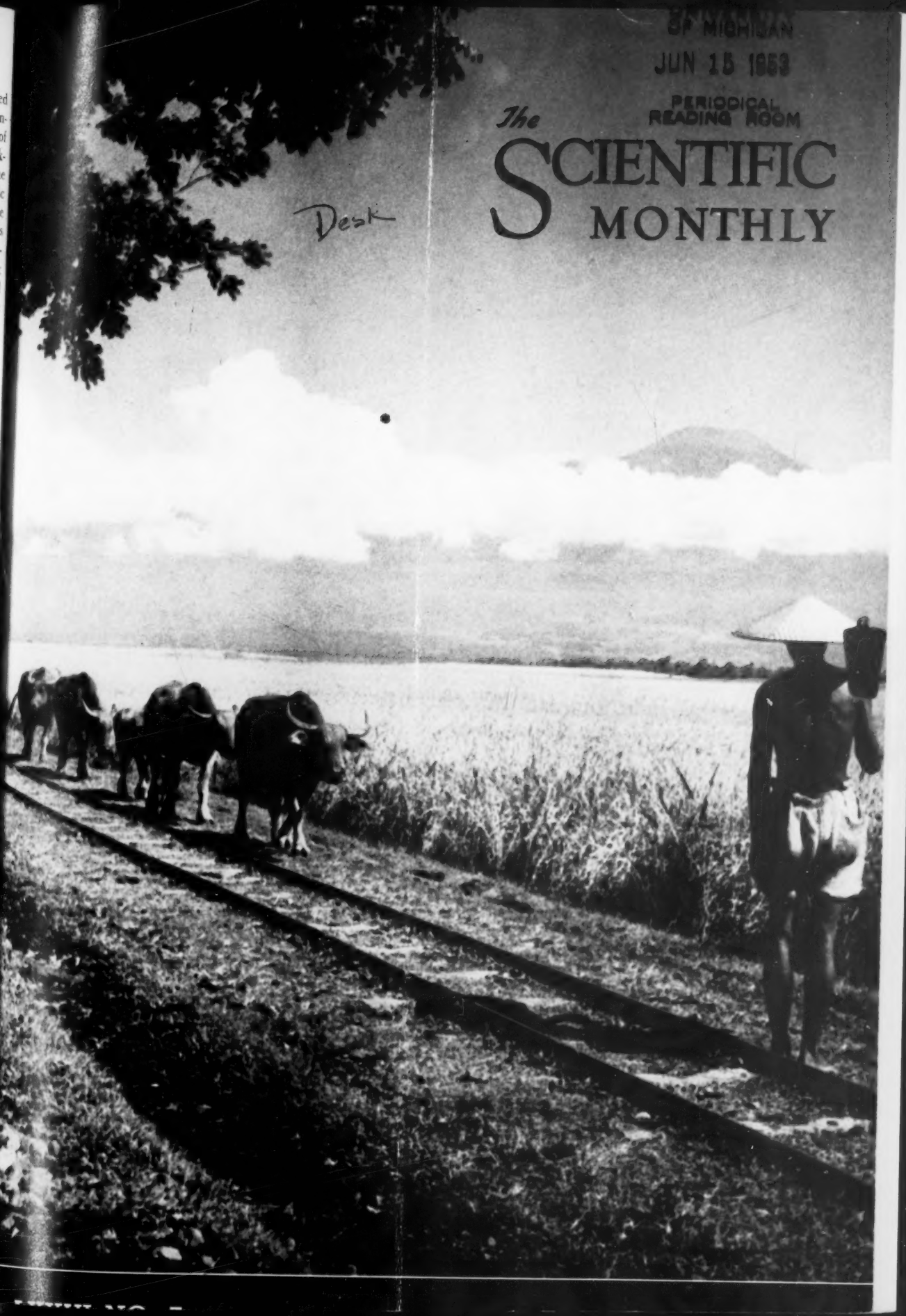

Pipes that grew without getting bigger

Cross-section of coaxial cable. To triple capacity, Bell Laboratories and Western Electric engineers had to make 1000 amplifiers work perfectly in tandem . . . feed repeater power along the same cable that carries messages . . . put signals on and off the line at numerous cities along the route without distortion.

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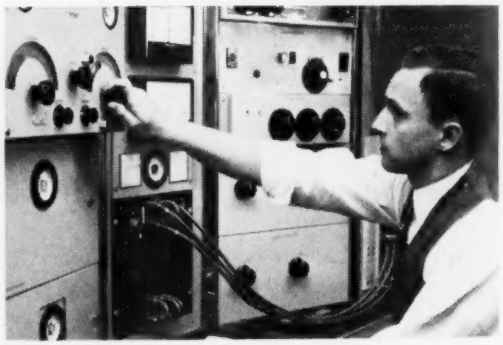
In improving the coaxial cable system, they created more than 20 years ago, engineers at Bell Telephone Laboratories devised a new way to give America still better telephone service, while the cost stays low.



Laboratories engineer tests new triple-duty coaxial system. It marks the first time that telephone conversations and television can travel through the same pipes at the same time. With a wider frequency band being transmitted, big problem was to eliminate interference between the two types of signals.

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Improving telephone service for America provides careers for creative men in scientific and technical fields

THE SCIENTIFIC MONTHLY

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A Magazine for Science and Public Affairs

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of nuclear fission

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THE
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MAY 1953

A Chronology of Postglacial Time in Eastern North America*

RICHARD J. LOUGEE

In 1928, following his discovery of evidence indicating the catastrophic draining of Glacial Lake Hitchcock and the sudden birth of the postglacial Connecticut River, the author of this article was commissioned by Isaiah Bowman to begin chronological investigations of the Ice Age for the American Geographical Society. A summary of his surveys is presented here for the first time.

RAISED marine shorelines extend to elevations hundreds of feet above sea level around the borders of glaciated North America, but it is not generally known that they preserve a record of uplift of the earth's crust which amounts to a history of postglacial time. This paper summarizes a larger study, and without citing the detailed evidence, presents an outline of postglacial history in eastern North America furnished by records of upwarping.†

Upwarped shorelines were originally horizontal, and their tilted attitude today gives a clue to the amount and type of land movement that has affected them. They offer, in fact, almost the only means by which prehistoric changes of level can be accurately measured. In the region of former Glacial Lake Agassiz, the Glacial Great Lakes, New England, Labrador, and Arctic Canada, where there are raised marine or raised lacustrine shorelines, or both, the shorelines rise progressively higher in directions converging on the former ice cap center in Hudson Bay, indicating that crustal upwarp has been associated with removal of ice weight.

Mechanism of Crustal Upwarp

Despite the apparent domelike pattern made by upwarped shorelines around the former ice center, a correct representation of postglacial upwarp is inverse to the form of a dome. If the earth's surface is considered in its relation to the shorelines when they were horizontal, prior to upwarp, it is found that much of New England that slopes seaward today then declined in a direction inland, and the crust must have been in a downwarped or basined condition toward the ice center. Upwarping has been a process of elimi-

* Based on a paper presented at the XVII International Geographical Congress, Washington, D. C., August 11, 1952.

† "Crustal warping" is defined as rock-bending in contrast to "faulting" or "folding."

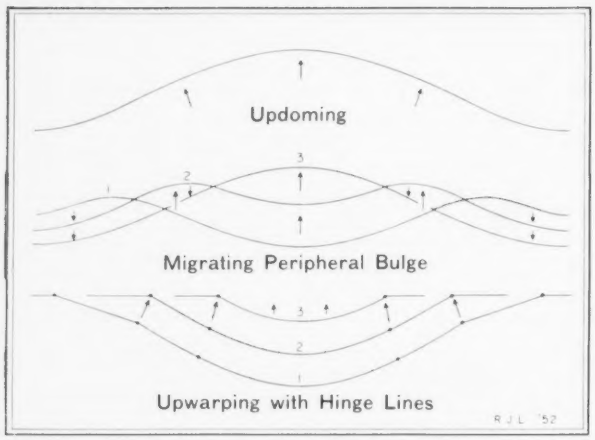

FIG. 1. Concepts of postglacial uplift.

nating this crustal basin. Within the immense area so affected, New England lies just inside the margin. Rise of the crust at the ice center has amounted to thousands of feet during and following deglaciation, and is in progress today around Hudson Bay, where the basined condition is not yet eliminated.

Authorities who interpret the tilted profiles of uplifted shorelines to indicate a direct rather than an inverted pattern of land movement describe the uplift as "updoming;"[1] others, conceiving the crust to be highly flexible, believe that a migrating "peripheral bulge" was succeeded by crustal sinking around the borders of the shrinking ice cap (Fig. 1). Neither of these views has satisfactorily explained the facts. The logic of updoming has mistaken apparent uplift for real; and no shorelines are known which decline in elevation toward the former ice center to substantiate a sunken bulge. Appearances of recent sinking on glaciated and unglaciated coasts alike are readily explained by postglacial worldwide rise of sea level. This so-called eustatic change of level resulting from the melting of glaciers has received scant attention in glacial problems, or the evidence for it has too often been ascribed to negative isostatic movements. If there has been crustal sinking to compensate for continental upwarping, associated with subcrustal undertow of magmas, it has left no signs on the continents, and must have taken place in the ocean basins, which have felt the weight of returning glacial meltwater.

It is not generally realized that raised glacial shorelines are emergent parts of the lower stages of sea level, contemporary with upward growth of coral islands (Fig. 2). Only in glaciated regions have Ice Age shorelines been upwarped by amounts exceeding the worldwide rise of sea level.

Unlike the complex mechanism that has been invoked to explain uplift by updoming and peripheral bulging, crustal upwarp from a basined condition was relatively simple. Upwarping affected not only the ice margins, but the whole glaciated area under the ice cap. Its mechanism resembled that of an old and brittle rubber ball responding to removal of pressure of a finger, except that the earth's crust, unlike rubber, has great rigidity, which accumulating stresses caused by removal of ice had repeatedly to overcome, allowing the rocky shell to rise with a jerky intermittent movement of separate crust blocks, like a broken mosaic. Progressive elimination of the basin was facilitated by a pattern of "hinge lines," or crustal cracks, encircling the basin, and perhaps combined with others radiating within it, which delimited regions under varying degrees of depression. Hinge lines are invisible, for they only bend or crack the crust and do not fault or dislocate it unless in some places local faulting is an added factor. They may be detected where shoreline surveys show changes of tilt in water plane profiles. The Algonquin Hinge Line, which was first discovered in surveys of the Glacial Great Lakes, has been traced 2000 miles (3219 km) across the North American continent from the region of Glacial Lake Agassiz to New England and New Brunswick.[2]

As successive uplifting movements took place,

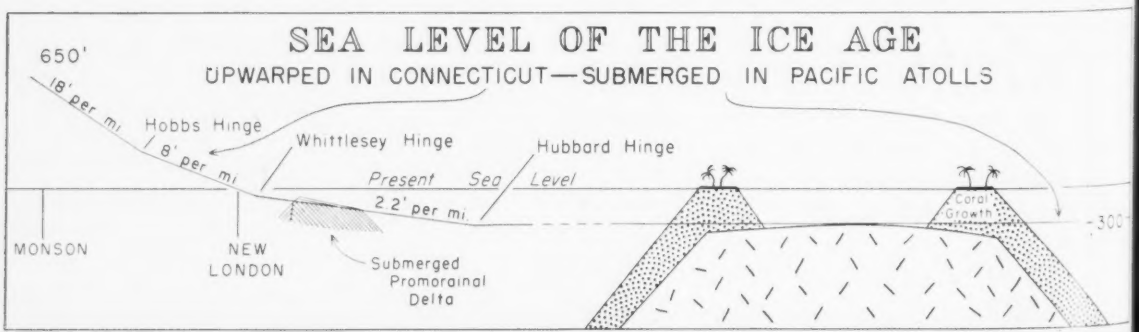

FIG. 2. Relationship of upwarped parts of glacial sea level (Leverett marine stage) to the submerged parts.

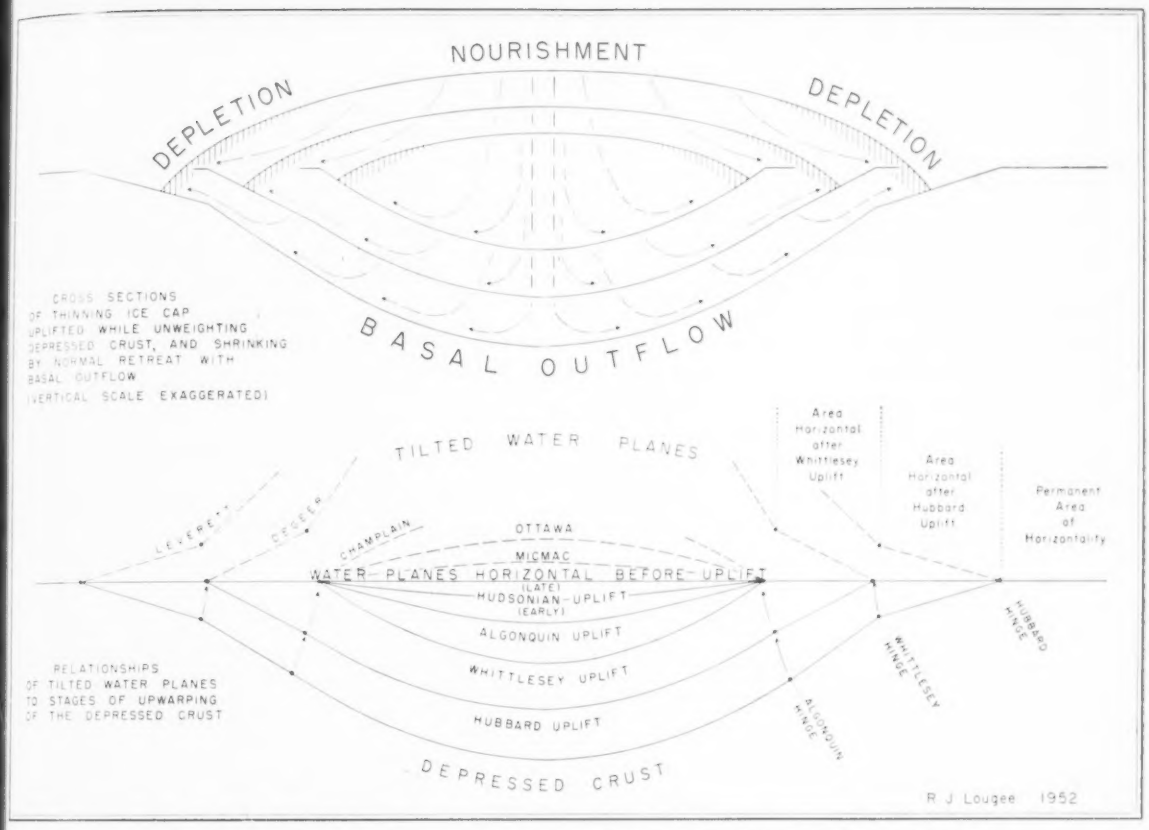

FIG. 3. Comparative diagrams of ice cap mechanics and mechanics of upwarping.

they were restricted to areas circumscribed by hinge lines of smaller circumference. Thus a clearly recognizable iceward shifting of the boundary of upwarp took place from outer to inner hinge lines, and vast regions early uplifted were not involved in later movements.

Two types of land movement took place during uplift. *Differential uplift* was characteristic of the peripheral parts of the basined region and showed its effects in "tilting" of the ice-marginal shorelines. At the same time *uniform uplift* took place in regions farther iceward or under the ice cap. Localities in southern New England on opposite sides of the Hobbs Hinge Line permit study of the two simultaneous movements and their effects on ice-marginal water levels.

Glacial Thinning in Relation to Upwarp

Postglacial upwarp was a response to thinning of the ice cap, for decrease in load on the land induced the upwarping. Contrary to a popular concept known as "downwastage," this shrinking in thickness was not due to melting down the top of the ice cap. If existing continental glaciers may be taken as reliable examples, deglaciation of the last North American ice cap was restricted to a "zone of depletion" (or ablation), probably extending not more than some scores of miles inward upon the high ice surface, which was two or three thousand miles across. This resulted in "retreat," or melting back, of the ice margin, exceeding the rate of forward movement of the ice.[3] Normal retreat of the ice margin induced a general reshaping and thinning of the whole ice cap in response to gravity (Fig. 3).

There has been a tendency among glacialists to overlook the element of time in ice cap mechanics, and to ignore gravity. Ice is a viscous substance, and gravity made stagnation impossible in the last ice cap. Bottom ice in contact with the earth's crust is at melting temperature, and highly plastic. Yet it never liquefies, as shown by the fact that in winter fine clay settles on the floors of glacial lakes, because no disturbing currents from any source enter the lakes at that season. Heat supplied to the base of an ice cap by terrestrial radiation promotes flowage and regelation before dissipating by conduction upward through the ice. Waning ice caps like those of Antarctica and Greenland are becoming thinner while snow continues to

CHRONOLOGICAL TABLE OF POSTGLACIAL TIME IN EASTERN NORTH AMERICA

Based on Successive Regional Uplifts and Stabilities
(R. J. Lougee 1932, and revisions to 1952)

LAKE AGASSIZ and GREAT LAKES	Stages Since the Last Glaciation	*NEW YORK–NEW ENGLAND–ACADIA*
Present Great Lakes	12 PRESENT TIME	*Present Sea Level* Titicut Indians (Taunton)
Postglacial Temperature Optimum Bell-Ottawa River diversion	11 LATE HUDSONIAN UPLIFT	Boston Weir Builders followed by 16 ft rise of sea level Emergence of St. Lawrence Valley
Post-Nipissing Great Lakes	10 MICMAC STABILITY	*Micmac Marine Stage*
Emergence of Ottawa Valley	9 EARLY HUDSONIAN UPLIFT	Isolation of Lake Champlain
Nipissing Great Lakes	8 OTTAWA STABILITY	*Ottawa Marine Stage*
Diversion of Lake Algonquin from North Bay outlet to Port Huron-Chicago Northeastward outflow of Lake Agassiz	7 ALGONQUIN UPLIFT	Rejuvenation of upper Connecticut River. Regressing stages of the Champlain Sea
Draining of Lake Iroquois Mohawk Outlet, Lake Iroquois Kirkfield Outlet, Early Lake Algonquin Campbell Stage, Lake Agassiz	6 CHAMPLAIN STABILITY	*Champlain Marine Stage* Ice retreat in Lower St. Lawrence Valley Coveville and Fort Ann Stages of Lake Vermont
Great Lakes diversion to Mohawk-Hudson Valley Birth of Niagara Falls Splitting of late-Whittlesey, Wayne, Warren and Lundy beaches Older beaches tilted north of Whittlesey Hinge Line	5 WHITTLESEY UPLIFT	Draining of Lake Albany; birth of ice-fed Hudson River Coastal regression beyond present shore: Massachusetts to New Brunswick Lake Upham, 2000 varves Ice retreat, Schuylerville, N. Y., to Middlebury, Vt.
Earliest Glacial Great Lakes: Maumee to Whittlesey. Lake Chicago. Retreat from Defiance Moraine to Port Huron-Alden Moraine Herman Stage, Lake Agassiz	4 DE GEER STABILITY	Birth of Connecticut River Lake Hitchcock, 4000 varves Lake Albany sea level lake *DeGeer Marine Stage* Ice retreat from Hartford, Conn., to Woodsville, N. H.
Ice retreat to Defiance Moraine Tilting north of Hubbard Hinge Line	3 HUBBARD UPLIFT	Coastal regression in Southern New England Cutting of Hudson Channel Continental shelf emergent
Great Lakes Basins Ice-Covered Milnor Stage, Lake Agassiz Small lakes in northern Ohio Ice retreat from terminal moraines; maximum crustal depression	2 LEVERETT STABILITY	*Leverett Marine Stage* Lake Hackensack, 2000 varves Ice retreat to Taunton-Monson-Middletown
Lake Arthur. Shelbyville-Bloomington Moraines	1 LAST GLACIAL CLIMAX	Lake Passaic Ronkonkoma-Harbor Hill Moraines

Stability south of the Algonquin Hinge Line. 100+ ft rise of sea level to Present Time. Up-Growth of Salt Marshes.

FIG. 4. Historical table of postglacial time: Correlations of the Middle West and the Atlantic Seaboard.

pile on at the center, but this thinning, in spite of continued nourishment, is proof that basal outward flow is taking place so fast that nourishment does not offset marginal depletion. The ice cap is literally "bleeding" to extinction. Crustal upwarping must be considered in the light of these interrelated factors, for uplift of the entire ice cap several thousand feet in elevation offset the effects of thinning, prolonged the deglaciation, and changed the floor profile on which basal ice moved outward and upward from the crustal basin. Readvances and moraine-building during times of uplift may have been manifestations of subglacial crustal adjustments in progress.

Intermittent Uplift, the Basis of Chronology

In Lake Agassiz, the Glacial Great Lakes, and New England it has been reliably established that upwarping, instead of taking place in a continuous movement during deglaciation, was spasmodic.[4] Five intervals of crustal movement were interspersed with five intervals of crustal stability. Because they cover the whole range of postglacial time the uplifts and stabilities may be made the framework for a chronology.[5] During each stability the glacial sea overspread parts of the depressed regions, but crustal upwarping and the draining of glacial lakes kept changing the patterns of land and water. Through the use of carbon-14, marine stages in eastern North America eventually may be found to correlate with marine stages in British Columbia and Alaska, or in such distant glaciated regions as Fennoscandia.

Present sea level is the marine equivalent of present time, corresponding to the concluding stages of the fifth uplift now in progress in Hudson Bay. Present time concludes the record of postglacial history, just as the last glacial climax is its beginning. These two units, added to the ten tectonic units, make a chronology of twelve stages of time since the last glaciation—each stage capable of transcontinental correlation, of portrayal in paleogeographic maps, of presentation in table form for convenient insertion of carbon-14 datings (Fig. 4), and of convenient analysis in the profiles of water planes (Fig. 5). Hitherto the dating of organic deposits has lacked significance because there was no accurate chronology of postglacial time. A tectonic time scale which subdivides the records of fossil-preserving water bodies, and which enumerates the earth movements and changes of sea level as they shifted shorelines and influenced the history and distribution of plants, animals, and early man, can give carbon-14 dates a meaningful position.

Where shorelines that abutted on the ice cap

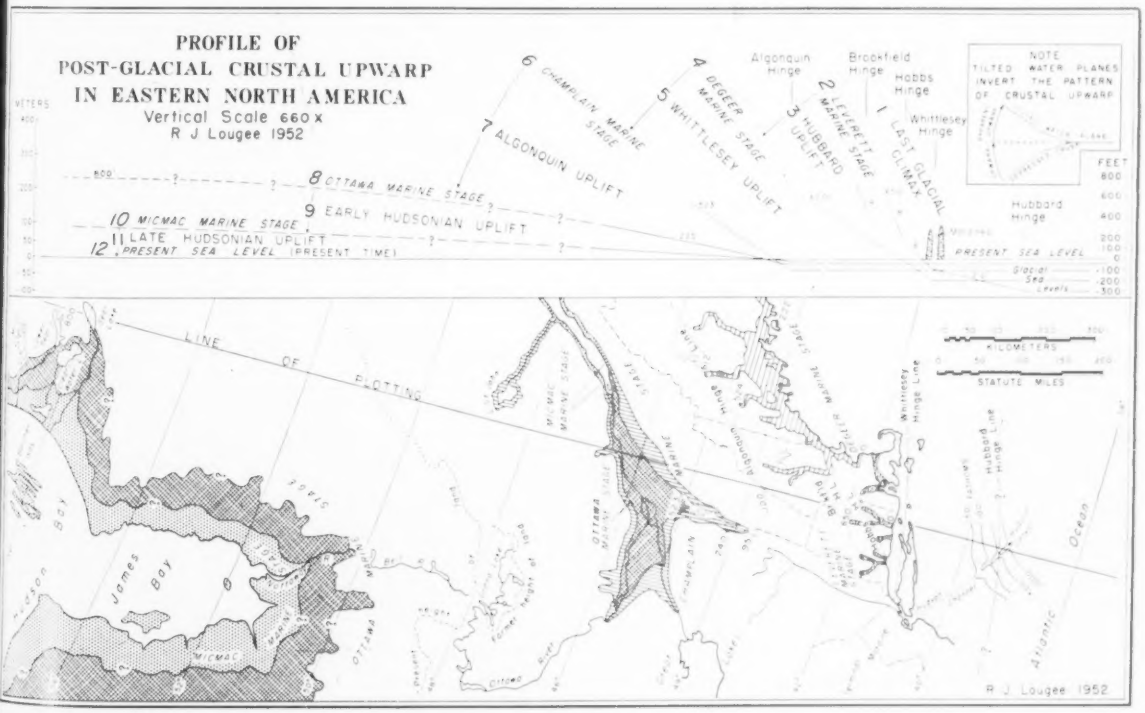

FIG. 5. Profile and map of postglacial upwarp between southern New England and Hudson Bay. For better portrayal, the Micmac water plane is drawn higher than its proper height along the line of plotting.

were altered by contemporary land movements, the ice border at the beginning and end of each of the first three uplifts may be accurately mapped. Thus, despite limited development of moraines in New England, ice borders at several important stages are traceable from the Atlantic coast to the Glacial Great Lakes and the basin of Lake Agassiz.‡ Where a marine water plane can be followed or projected to a hinge line marking a termination of warping, the lower position of glacial sea level at that stage may be calculated, as shown in Figure 5.

Measurement of how much vertical upwarp has taken place at the former ice center is theoretically possible by totaling the differential movements of the separate uplifts. In mose cases, however, differential movement extended some distance under the ice, so that part of the record is lost, and the total amount measurable from the region of the terminal moraines to the Hudsonian ice center, amounting to 2500 feet (762 m) is but a minimum figure at best. Additional depression in excess of 500 feet (152 m) still exists, accounting for the continued submergence of Hudson Bay.

If the modulus of crustal upwarp is indicated in the basin of ancient Lake Bonneville in Utah, where an uplift of 168 feet (51 m) took place in response to evaporation of 1000 feet (304 m) of water,[6] then the depression that centered on Hudson Bay, amounting to a minimum of 3000 feet (914 m) as measured in the present surveys, may indicate a former ice thickness of about 20,250 feet (6.115 km),§ or 3.8 miles, near the center of the last ice sheet.

‡ It is the opinion of the writer that there is no justification for a tripartite division of time based on till deposits (Tazewell, Cary, Mankato) currently employed in the Middle West. Continuous till sheets may be mapped over large areas, but in the present state of their analysis they do not provide definite and measurable factors for delimitation of time.

§ The equation based on columns of water is 168: 1000 = 3000: 18,000.

Outline of the Twelve Stages of Postglacial Time

1. *Last Glacial Climax* (Fig. 6). At its climax the last ice sheet built a massive moraine which can be traced from the Atlantic to the Pacific, or two moraines, as in southern New England or Ohio. Moraine elevations as much as 333 feet (101 m) on Long Island indicate a thickness of

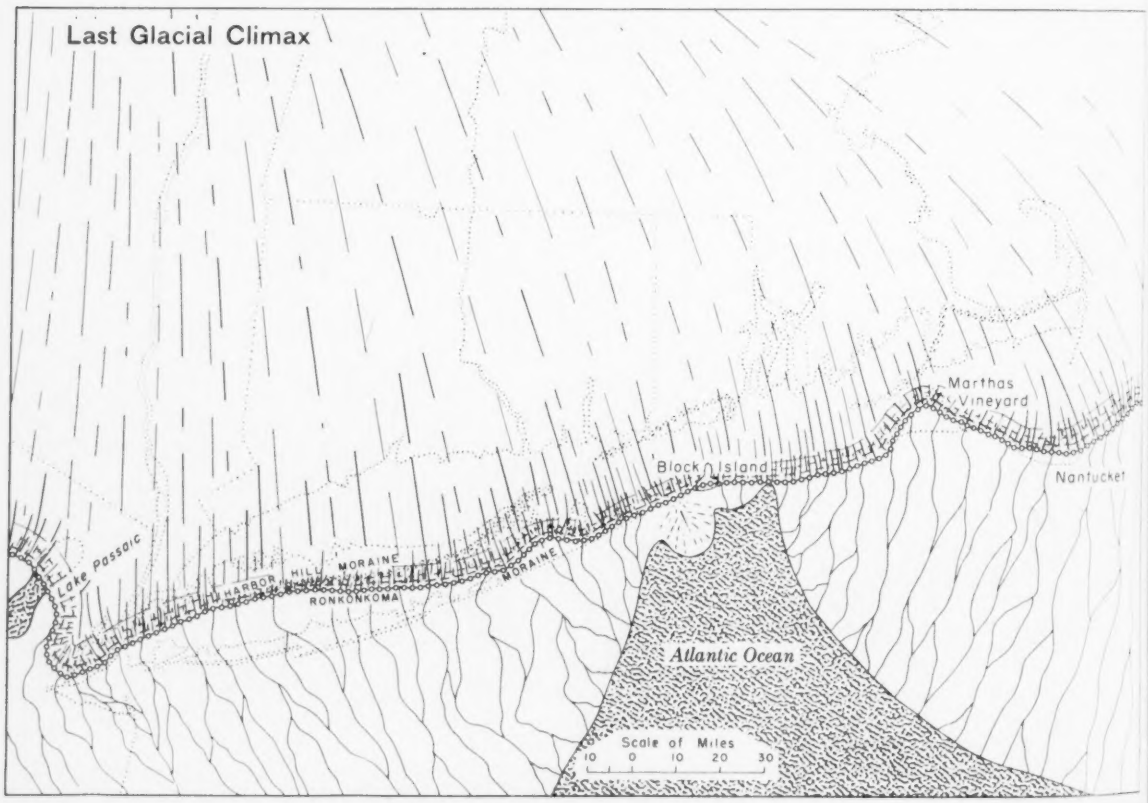

FIG. 6. Last glacial climax.

at least 1000 feet (305 m) of ice in Long Island Sound. Sea level was at or near its lowest position because of abstraction of sea water to form ice caps, and the continental shelf was above sea level. Ice-fed rivers aggraded wherever they spread outwash on land beyond the moraines. Outwash plains associated with moraines on Long Island extend below present sea level, presumably to the submerged deltaic edge of the continental shelf. An exception is found in a promorainal delta on the sea floor south of Block Island, marking one point where meltwater or discharges of ice-dammed lakes from north of the moraine met the shore of the ocean abutting on the ice front at this stage (Fig. 7).

It is not generally recognized that the submerged Hudson Channel which is intrenched in the surface of the continental shelf southeast of New York City could not have existed during the glacial climax, while meltwater streams were aggrading beyond the moraines. Neither could this channel have survived from earlier times under the conditions of aggrading glacial rivers. The Hudson Channel came into being at some time after construction of the outwash plains, or not earlier than a change to erosive conditions following ice retreat from the terminal moraine on Staten Island.

A number of ice border lakes such as Lake Arthur in northwestern Pennsylvania, and Lake Passaic in New Jersey, correlated with the last glacial climax and had shorelines partly inside and partly outside the terminal moraine.

2. *Leverett Stability and the Leverett Marine Stage* (Fig. 8). Recession of the ice border from the terminal moraines while crustal depression was at maximum allowed the glacial sea to spread northward so that it surrounded and made an island of the southeastern parts of Massachusetts,[7] at the same time penetrating the larger valleys of southern New England.[8]‖ Lake Hackensack in northern New Jersey, and the Glacial Tappan Sea in the Hudson Valley, south of the Highlands, may have had connections with the submergence in Long Island Sound by way of the East River. These Leverett marine stage estuaries were kept fresh by meltwater converging on a seaward outlet now submerged east of Block Island. The Leverett water plane in each valley is accurately marked by ice-marginal deltas built at successive positions of the ice border. In the case of the Willimantic Valley estuary, the Leverett waters

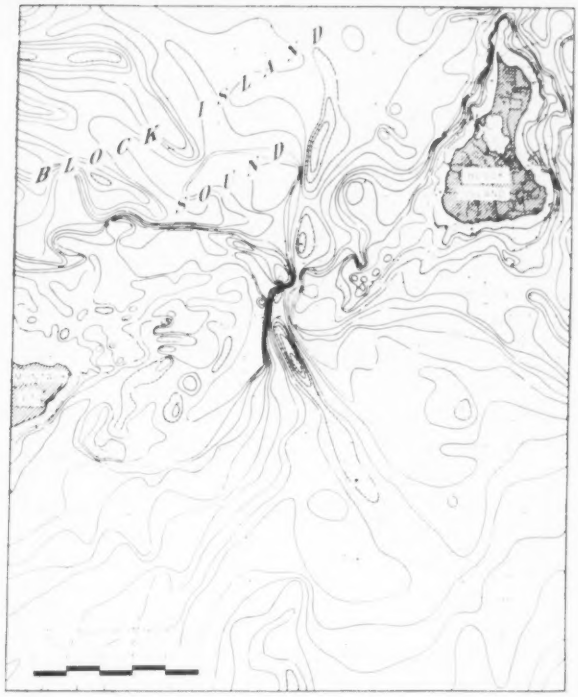

FIG. 7. Submerged promorainal delta south of Block Island (from Coast and Geodetic Survey Chart No. 1211).

completely transected the state of Connecticut, and the water plane extended above and beyond the present 612-foot (186 m) drainage divide into the Chicopee Valley of southern Massachusetts. In this and several other estuaries an abrupt northern termination of the water plane shows exactly how far the ice front had retired before uplift concluded the stability.[9] Approximately 2000 varves were formed in the clay beds of the Hackensack basin during this slow recession.

Today elevations on the Leverett water plain rise increasingly higher inland at rates determined by hinge lines. Starting from the initial or Hubbard Hinge Line, the tilt rates are calculated or observed to be 0, 2.2, 8, 18, and 24 feet per mile, measured northwesterly across southern New England. The figure of 18 feet per mile in northern Connecticut and central Massachusetts is double the maximum tilt observed in the Baltic. This exceptional upwarp marks a zone of previous great downwarp of the crust slightly iceward from the terminal moraines. At the northern border of Connecticut in the Willimantic Valley, a marine limit of 650-feet elevation (198 m) is recorded in contrast to zero elevation on the same water plane at New London on the Connecticut coast. Observable emergent parts of the water plane, projected southward, are in alignment with the submerged

‖ Housatonic, Naugatuck, Quinnipiac, Connecticut, Willimantic, Quinebaug, French, Blackstone, Taunton.

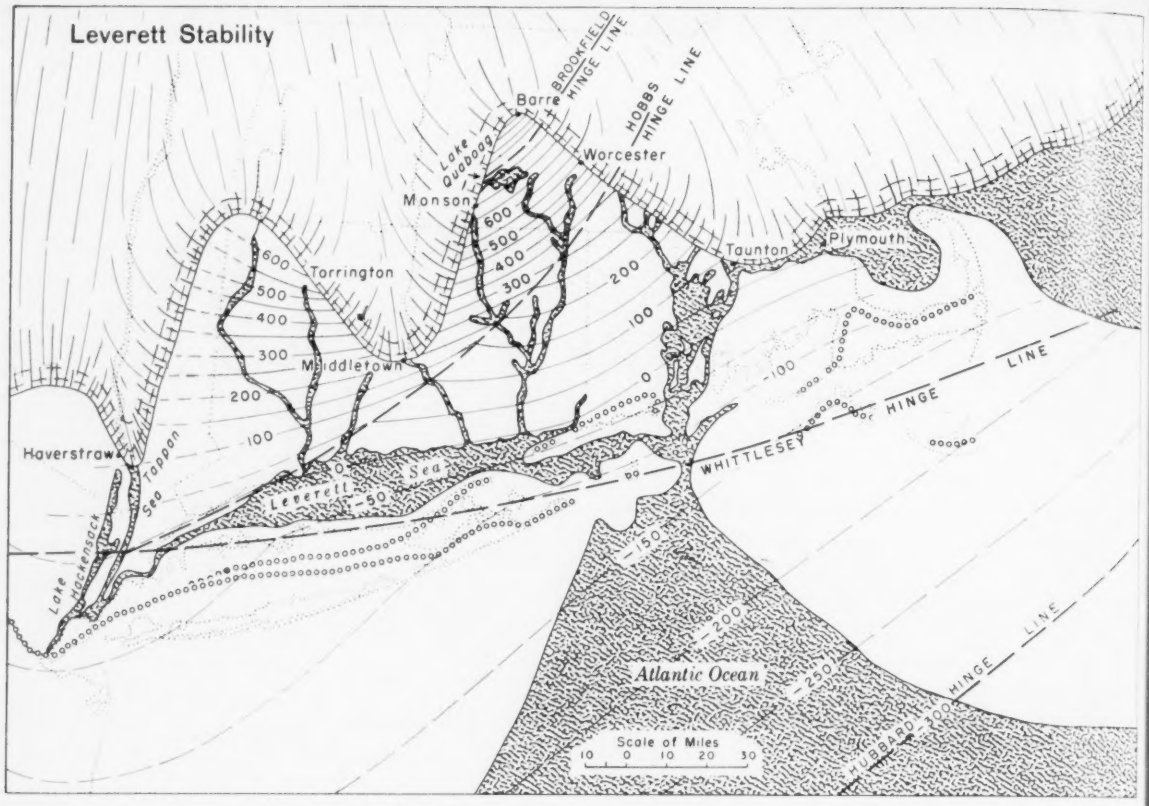

FIG. 8. Leverett stability, with isobases on the Leverett water plane.

promorainal delta 140 feet (43 m) below present sea level, south of Block Island (Fig. 2). The water plane must bend to gentler gradient where it crosses the Whittlesey Hinge Line in Long Island Sound, but horizontality cannot be reached until it encounters an initial or Hubbard Hinge Line. Location of the Hubbard Hinge Line depends on how much sea level has risen since Leverett time. If Leverett sea level lies at or below −300 feet (−91 m), where some calculations place it,[10] the Hubbard Hinge Line is at least 100 miles (161 km) south of Long Island.

3. *Hubbard Uplift* (Fig. 9). When the ice had melted back to a position marked by northern limits of several Leverett estuaries, and had thinned until its border consisted of great lobes in the Hudson and Connecticut lowlands, and over the Boston basin, with deep interlobates in the intervening highlands, the first great regional land movement commenced. Starting at the Hubbard Hinge Line, a wave of permanent uplift progressed northward, tilting successive crust blocks as it shifted to more northerly hinge lines. Hubbard uplift may have tilted an initial stage of Lake Agassiz represented by the Milnor beach. It is well recorded in small glacial lakes in Ohio, south of and antedating uncovering of the earliest Glacial Great Lakes.[11] Abandoned shorelines of Glacial Lake Arthur in western Pennsylvania, and Lake Passaic in New Jersey were tilted alike about 2.2 feet per mile.[12] These lake basins are located iceward of the Hubbard Hinge Line, and south of the Whittlesey Hinge Line. Tilt rates increase in directions generally northwestward across eastern Connecticut and central Massachusetts, but not until northern parts of the central highlands of Massachusetts were uncovered did the wave of differential uplift reach glacial lakes in the upper Ware and Millers river valleys, which are tilted to the extreme of 24 feet per mile.[13]

The most informative records of Hubbard uplift are in New England, where Leverett estuaries were abruptly drained and replaced by powerful glacial rivers. Emergence was more or less responsible for creating high waterfalls on the Housatonic and lower Connecticut rivers.¶ Beginnings of uplift at New Haven, Connecticut, caused ice-fed Mill

¶ Height of the Housatonic Falls below New Milford, Connecticut, exceeded 130 feet (40 m);[14] outlet rapids of Lake Hitchcock below Middletown descended 150–200 feet (46–61 m); and falls at the mouth of Salmon River in East Haddam, Connecticut, fell an estimated 190 feet (58 m).

River to intrench in the widespread 40-foot plain of deltaic outwash in that city, removing part of it to form the immense river terrace 20 feet lower, where the business center of the city is located. As uplift proceeded, Farmington River, flowing southward from the ice border, advanced to New Haven through the Quinnipiac basin, where for at least 800 years there had been a Leverett estuary accumulating red varved clays. These clays the Farmington overspread with white sands and gravels of the Wallingford sand plain before incising the basin to below present sea level.[15]

All rivers from the Hudson eastward to Narragansett Bay were extended seaward beyond the present coast. Stream terracing and intense activity of the westerly wind accompanied exposure of the sea floor; and the Hudson River, spilling southward through the terminal moraine at the Narrows as the lower Hudson Valley was tilted, cut the Hudson Channel as it intrenched in the continental shelf.

Although ice-dammed lakes have been a common feature in New England recessional history, Hubbard uplift was notable for a number of classic examples, which formed constantly changing patterns along the ice border. A steplike series of lakes draining from one to another, or sometimes coalescing, was formed in the northward sloping valleys on the west side of the Boston ice lobe; a similar series formed along the eastern margin of the Connecticut Valley ice lobe. Waters released by drainages of these lakes rushed along the ice borders, building kame terraces and cutting hillside channels, or sometimes discharging bedload over waterfalls to pound out spectacular rock gorges like Purgatory Chasm in Sutton, Massachusetts, or Toffit Falls Chasm where Lake Nashua drained away in Littleton, Massachusetts. Release of ice-dammed Farmington Lake at Tariffville, Connecticut, opened the present northward course of Farmington River through the empty lake basin and diverted the river from its temporary southward course to New Haven. Along the east side of the Connecticut Valley the discharges of ice-dammed lakes built torrential deltas and deltaic kame terraces along the shore of newly formed Lake Hitchcock in the stem of the valley, in so doing accurately recording several early stages of the lake, which was being tilted by land movement. Shores of all lakes of this period, although tilted variable amounts depending on their location and time of existence, are more steeply inclined than shores formed after the Hubbard uplift.

Hubbard upwarp approximated 300 feet (91 m)

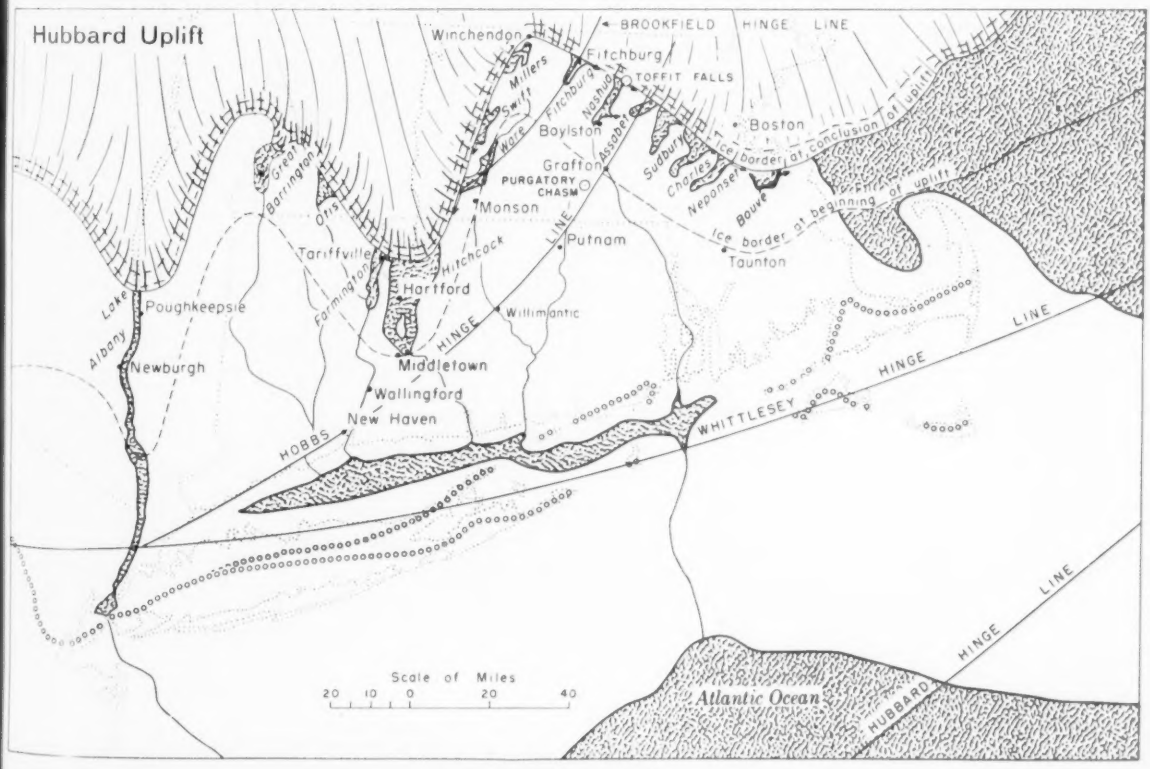

FIG. 9. Hubbard uplift.

in Long Island Sound, and perhaps 1000 feet (305 m) in central Massachusetts. So great was the tilting in the region of Worcester that the location of the divide between Blackstone and Nashua valleys has been shifted northward as much as 11 miles (17.8 km) from Grafton, Massachusetts, to Boylston. Upwarping may have been associated with earthquakes which caused land slips along the margin of the continental shelf. Submarine slides simultaneous with the addition of deltaic material to the shelf from rivers draining the ice are believed to have produced the short, deep submarine canyons indenting the continental slope from Georges Bank to Cape May. Trains of fresh sand extend from the foot of the slope far out upon the floor of the Atlantic basin,[16] and transportation of this material by gravity currents may have been generated by shaking of the sea bottom.

4. *DeGeer Stability and the DeGeer Marine Stage* (Fig. 10). Hubbard uplift was over before the ice uncovered Boston. Then, while the ice border melted back 140 miles (230 km) to Woodsville-Littleton in northern New Hampshire, there was complete stability of the crust. As the ice retreated northwestward across depressed New England, the second marine inundation, or DeGeer stage, of the glacial sea overspread coastal lowlands of eastern Massachusetts, New Hampshire, Maine and New Brunswick, penetrating to the foothills of the White Mountains, and the base of Mount Katahdin. Melting back of the glacier face standing in this ice pack–covered sea left trails of gravel at the submerged mouths of meltwater tunnels. These deep-water deposits are today some of the most extensive esker systems in the world.[17] At places where they were built up to form proglacial deltas, like the "Promenades" at Portland, Maine, they record the water level with their flat tops.

As a result of later Whittlesey uplift the DeGeer marine limit water plane is tilted so that it projects above present sea level along a zero isobase extending from Cohasset, Massachusetts,[18] near Boston, to Yarmouth, Nova Scotia, from which line it extends inland in a northwesterly direction to elevations exceeding 600 feet (183 m) in central Maine. Iceward from the Whittlesey Hinge Line the earth's crust of DeGeer time was depressed toward the ice, but regions well beyond the ice

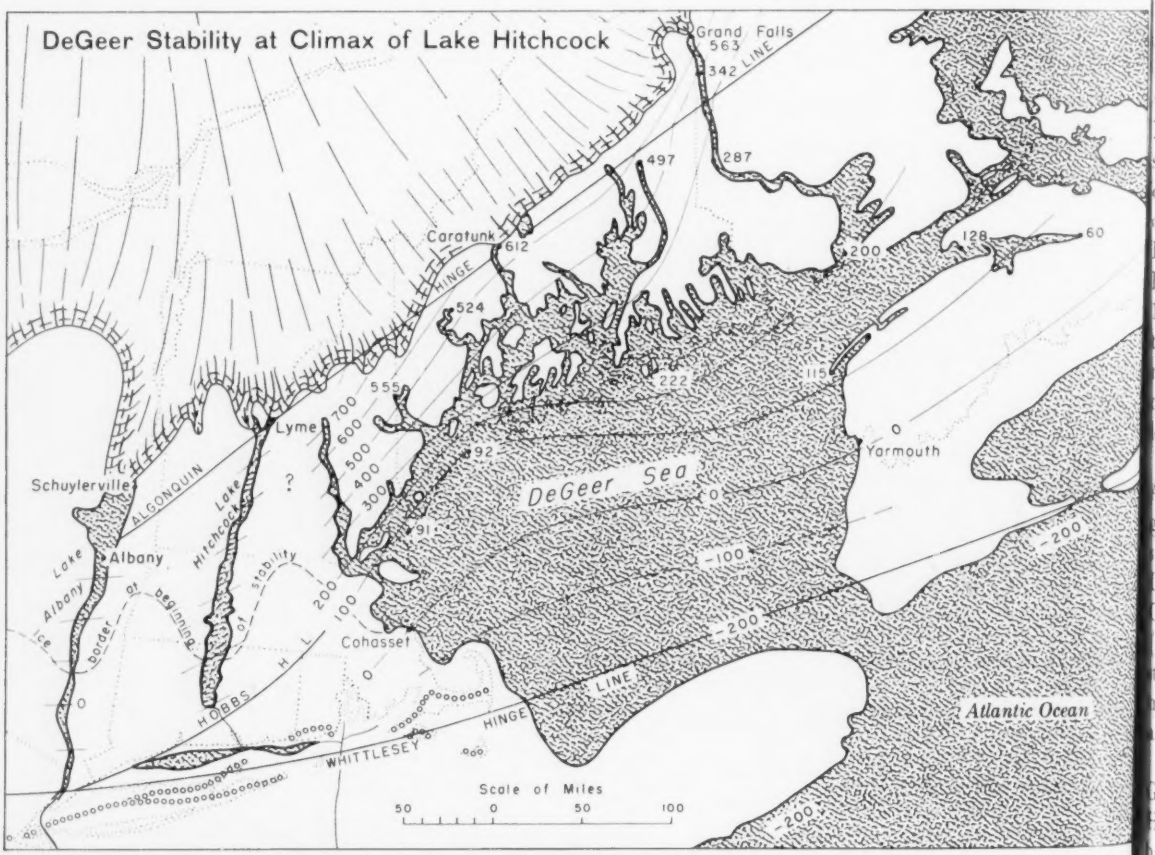

FIG. 10. DeGeer stability at climax of Lake Hitchcock, with isobases on the DeGeer water plane.

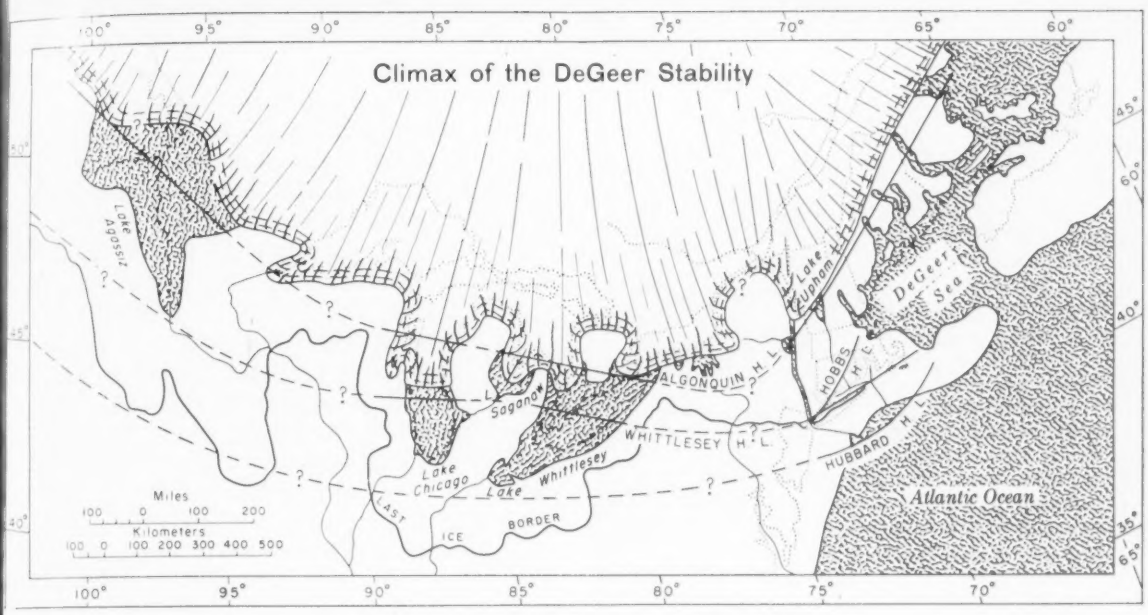

FIG. 11. Climax of the DeGeer stability.

border were more emergent than now, because of previous Hubbard upwarp and the lower sea level. The continental shelf and the fishing banks formed a belt of elevated land enclosing the DeGeer Sea in the Gulf of Maine, and along this land bridge the pine barren flora of New Jersey migrated to Nantucket and beyond.[19] Cape Ann in Massachusetts, highlands in coastal parts of Maine, and all of Nova Scotia were then islands. Melting back of the ice border in the Connecticut Valley allowed Lake Hitchcock to expand from Tariffville and Hartford, Connecticut, to Lyme, New Hampshire, 160 miles (257 km) north of the drift blockade that controlled the lake near Middletown, Connecticut. Lake Hitchcock varves record 4000 years of remarkably stable crustal conditions that followed the uncovering of Hartford.

DeGeer stability coincides in time with Lake Albany in the Hudson Valley, a fresh-water body graded to the DeGeer stage of sea level via the submerged Hudson Channel. It also correlates with Lakes Maumee and Whittlesey in the Glacial Great Lakes, and an ice recession of 250 miles (402 km) in the Middle West during the Herman stage of Lake Agassiz (Fig. 11).[20] Mastodon remains in half a dozen localities in New England are referable to DeGeer time.

5. *Whittlesey Uplift* (Fig. 12). The earliest Glacial Great Lakes came into being following Hubbard uplift, or not until after the ice border had melted back 150–200 miles (229–322 km) from the terminal moraines in southern Ohio. As ice in the Erie basin melted back from its position controlling Lake Whittlesey, an uplift began which was the first to leave a record in the Glacial Great Lakes, although it is second to the Hubbard in the history of New England.[21] The area uplifted was circumscribed by the Whittlesey Hinge Line, which embraces Lake Agassiz, extends eastward across the Michigan and Erie basins, and passes south of New England in the vicinity of New York City and Long Island Sound. Iceward of this line and including much of the region tilted in Hubbard uplift, the land began to rise as ice retreated from moraines near Grand Falls, New Brunswick, at Littleton and Woodsville, New Hampshire,[22] and the Port Huron–Alden morainal system of the Great Lakes.

In the Glacial Great Lakes the recorded rise of land began on the Whittlesey Hinge Line, but the boundary of movement gradually shifted iceward, until at the conclusion of the uplift it had reached the Algonquin Hinge Line. Earthquakes on the Hobbs Hinge Line in Connecticut, which forms a great crustal crack branching off from the Whittlesey Hinge Line, were forerunners of the movement in southern New England; and by disrupting a till blockade which had endured at the outlet of Glacial Lake Hitchcock for 4000 years, suddenly drained the lake when the ice front stood at Lyme, New Hampshire, and gave birth to 90-foot-lower Lake Upham, and the postglacial Connecticut River.[23] Fault dislocations in the DeGeer water plane, associated with Whittlesey upwarping, ap-

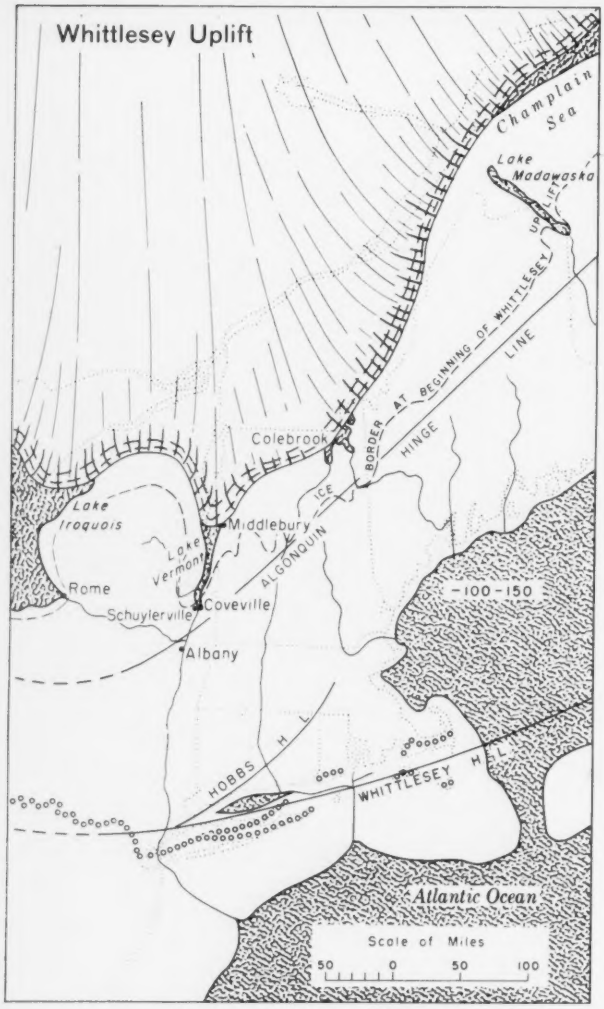

FIG. 12. Whittlesey uplift.

pear along northerly extensions of the Hobbs Hinge Line in southern New Hampshire, and near Portland, Maine, bordering Casco Bay.[24]

Subsiding stages of the DeGeer Sea in Maine, unlike the previous DeGeer upper marine limit, are generally fossiliferous, a fact which may indicate increased salinity as rising sea level inundated Georges Bank and other parts of the cuesta east of the Gulf of Maine. As land rose, rivers were extended to the receding shore. Many, including the Merrimac, Androscoggin,** Kennebec,[25] Penobscot, and St. John, were for a long time fed by the retiring ice border in the White Mountains of New Hampshire and in northwestern Maine and New Brunswick. The coast finally lay eastward of the present shore, somewhat below the 17-fathom (30 m) line, marking the next ensuing, or Champlain, stage of glacial sea level. Sea floors were exposed from Cape Cod to the Bay of Fundy, and rivers spread sand over the plains of marine clay before dissecting them. This was the period of greatest river terracing in New England history. River bluffs facing the blast of a strong prevailing westerly wind became a principal source of loess and dune sand, which were deposited on the east sides of valleys before vegetation took hold.††

In addition to the host of new streams that resulted from the emergence, newly formed lakes appeared in localities previously marine, such as Sebago and the Belgrade lakes of Maine. Rivers which had acquired northward courses resulting from northward drainages of ice-dammed lakes flowed increasingly slowly as tilting decreased their gradients. Some turned back into lakes, which have since become aggraded with alluvium and swamp deposits that make possible a minimum slope for flow.‡‡

In the Hudson Valley, Lake Albany was completely drained by Whittlesey tilting, and replaced by a powerful Hudson River, ice-fed from Lake Iroquois in the Ontario basin, and from the Coveville stage of Lake Vermont in the Champlain basin.[27] Hudson Channel on the continental shelf, through which the river carried away immense quantities of Albany clay, was not altered by the uplift as it lay south of the Whittlesey Hinge Line, passing through New York City. Submarine charts show the lower end of this channel terminating in deltalike deposits at a depth of 30–40 fathoms (55–73 m), which appear to be penetrated by the head of the Hudson Submarine Canyon. Accordingly the canyon may be no older than Whittlesey uplift.

** Androscoggin River wandered across the coastal belt of Maine and acquired a wholly new postglacial course. After bypassing the Salton basin of Androscoggin Lake and contributing sand to the "Desert of Maine" in Freeport, the Androscoggin advanced into the structural valley of the Kennebec River at Brunswick, damming it with a delta before slipping northward off the dam to join the Kennebec in Merrymeeting Bay. From this point the confluent rivers escaped seaward across a rock sill to reach a more easterly structural valley which leads to the city of Bath.

†† Charles River dissected its DeGeer marine limit delta at Watertown, Massachusetts, and advanced across the emergent clay plains of the Boston basin to points east of the present harbor, spreading sheets of sand and gravel which are not to be confused with DeGeer deltas and outwash of earlier date. This material the coastal winds worked into dunes and ventifacts that are encountered in excavations below present sea level in the Boston Back Bay.[26]

‡‡ Streams retarded by Whittlesey uplift include the Wallkill in New York, the lower Farmington in Connecticut, the Quabaug, Neponset, Charles, Sudbury, Concord, and Shawsheen in Massachusetts, the Contoocook in New Hampshire, and the Messalonskee in Maine.

At least 2000 varves of Lake Upham record connections of the head of the Connecticut Valley with ice as the lake was tilted,[28] and before the ice cap became restricted to the St. Lawrence watershed. Whittlesey upwarping split the beaches along the 70-mile length of Glacial Lake Madawaska in headwaters of the St. John River,[29] and may be recorded in the earliest evidences of marine penetration of the lower St. Lawrence Valley. But Whittlesey uplift ended, and stability followed as the ice uncovered Middlebury, Vermont, long before marine waters entered the Champlain basin.

At the end of the uplift the greater part of New England, or that lying between the Whittlesey and the Algonquin hinge lines, had been raised to the position it has today, leaving the DeGeer marine limit plane tilted upward to the northwest about 4 feet per mile. Tilt rates are less in Nova Scotia and New Brunswick, but are 5.5 feet per mile in the Hackensack basin of northern New Jersey and southern New York, where a combination of Hubbard and Whittlesey uplifts is recorded.

Migrating plants gained hold on the land as fast as ice or the retreating waters uncovered it. At Colebrook, New Hampshire, in the northern end of the Connecticut Valley, a tundra flora of *Dryas* and heaths with birch, poplar, and willow flourished beyond the ice border, its fossilized leaves preserved in lake clays[30] (Fig. 13). These occurrences of *Dryas*, now extinct in New England, are the first, and so far the only ones discovered in eastern North America, although fossil *Dryas* is common in the glacial deposits of Europe.

FIG. 13. Fossil leaves of *Dryas* flora preserved in clay, from glacial lake beds, Colebrook, New Hampshire.

6. *Champlain Stability and the Champlain Marine Stage* (Fig. 14). Whittlesey uplift was followed by crustal stability coinciding with early stages of Lake Algonquin in the Great Lakes, and with ice recession in the Champlain Valley. Two long-lasting and stable stages of Glacial Lake Vermont developed in succession, followed by a stable stage of glacial marine waters bringing whales and shellfish into the Champlain Valley from the St. Lawrence Valley as the ice border uncovered the northern spurs of the Green Mountains of Vermont. The water plane of this brief earliest stage of the Champlain Sea declines in elevation southwestward today from 523 feet (159 m) at Covey Hill, Quebec, to 331 feet (101 m) at Brockville, Ontario, in the St. Lawrence Valley, beyond which point the sea could not penetrate farther toward the Ontario basin. From Covey Hill the same water plane declines southeastward about 5 feet per mile in the Champlain basin to intersect the present lake surface at 95-feet elevation (28 m) near Whitehall, New York. If projected on southward it reaches a depth of 100 feet (30 m) below present sea level, where it is presumed to become horizontal on encountering the Algonquin Hinge Line at Hanover, New Hampshire.[21] According to these calculations, the earliest Champlain marine stage in Vermont correlates with a shoreline submerged at the 17-fathom line along the eastern and southern New England coasts, as elsewhere in the world where not deformed by crustal movements.

Probably the best evidence for the Champlain stability in New England is furnished by the three parallel and equally tilted water planes (two lacustrine and one marine) in the Champlain basin of northwestern Vermont.[31] Champlain stability coincided with the uncovering of the St. Lawrence trough at a time when the depths of water were so great that the only shores of the period are now high on the south slopes of the St. Lawrence Valley, those to the north having been faces of the retiring ice. Eventually, when land was uncovered on the Laurentian side of the St. Lawrence, the stability was over, and active Algonquin uplift was in progress. One of the few regions where the Champlain water plane can be traced in a direction of maximum tilt is in the basin of Lake Champlain, where the trend of the isobases is

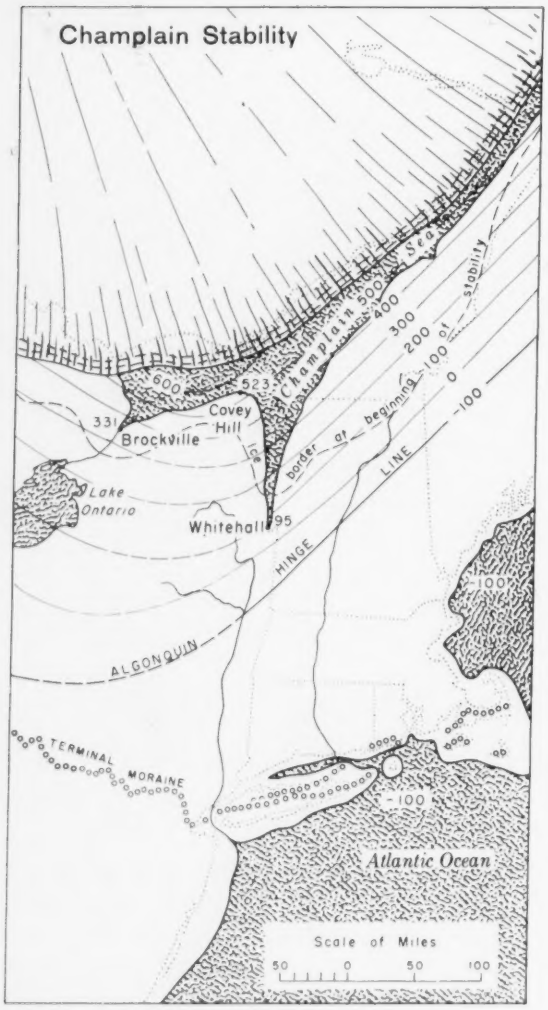

Fig. 14. Champlain stability, with isobases on the Champlain water plane.

across the beach lines, rather than parallel to them as in the lower St. Lawrence Valley; and where elevations on both sides of the basin can be compared.

7. *Algonquin Uplift* (upwarp included in post-Champlain isobases, Fig. 14). Following the Champlain stability, upward movements of the crust began north of the Algonquin Hinge Line, and have continued intermittently on this boundary line to present time. The Algonquin Hinge Line is now as accurately mapped in New England as it had been earlier in the Middle West. It roughly parallels Appalachian structure, in contrast to a southeasterly direction across the Great Lakes. Location of the junction of the two parts of the line in New York state, and its nature, are as yet undetermined.

Shorelines iceward from the Algonquin Hinge Line, if formed prior to Algonquin uplift, preserve complete records of tilting that was due to post-Whittlesey upwarping. Such are the Campbell beach of Lake Agassiz, the early (Kirkfield stage) beach of Lake Algonquin, the Iroquois beach in the Ontario basin, the highest Champlain beach in Vermont, and the initial shore of Lake Upham in the Connecticut Valley. These and all later water planes have a spectrumlike convergence toward the Algonquin Hinge Line, which permits three distinct stages of post-Whittlesey land movement to be identified and correlated, from the Middle West to the Province of Quebec and New England.

The Champlain water plane in Vermont and in the lower St. Lawrence Valley is tilted 5 feet per mile. Algonquin upwarp, as here defined, accounts for the uppermost 2.8 feet of this amount, which was accomplished before the stability of Ottawa time. Algonquin movement was in progress as the Laurentian side of the Ottawa and St. Lawrence lowlands were relieved of their ice cover. A weak upper marine limit associated with massive ice-marginal deltas and constantly degrading tributary stream deltas characterizes the subsiding stages of the Champlain Sea. Shore elevations of these metachronous water levels rise to 620 feet (189 m) at Lake St. John in the Champlain estuary of the Saguenay Valley, 690 feet (210 m) on Kingsmere Mountain at Ottawa, and 551 feet (168 m) at Mattawa, Ontario, where the North Bay outlet river from Lake Algonquin built a delta into the Ottawa Valley estuary. Marine fossils attributable to late stages of the Champlain submergence are plentiful as far inland as Pembroke, Ontario.

Algonquin uplift took place while the ice border was associated with middle and late stages of Lake Algonquin. In northern parts of Lake Agassiz and the Glacial Great Lakes this and succeeding uplifts have produced higher tilt rates than the earlier Whittlesey uplift. In New England, only those regions northwest of the Algonquin Hinge Line have been affected by post-Whittlesey movements. The Connecticut Valley northwest of the Algonquin Hinge Line at Hanover, New Hampshire, has been given increased inclination amounting to several feet per mile; and the shoreline of Lake Upham, which is tilted 4 feet per mile south of Hanover, is tilted 9 feet per mile north of Hanover, where it bears the combined record of Whittlesey, Algonquin, and Hudsonian movements. Southern and eastern New England outside the Algonquin Hinge Line has remained stable, or an "area of horizontality," since the Whittlesey uplift.

8. *Ottawa Stability, and the Ottawa Marine*

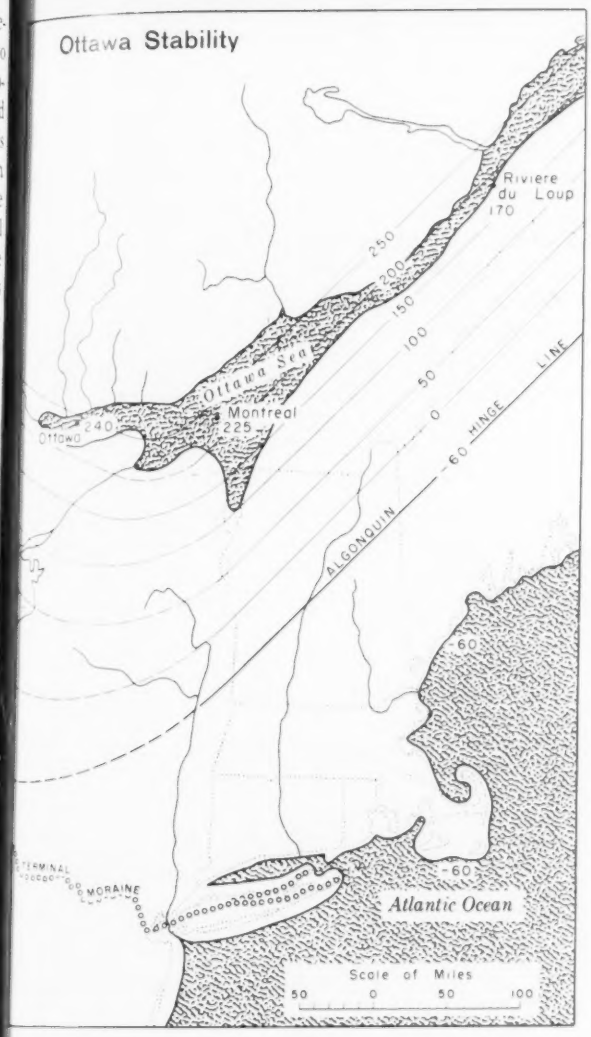

Fig. 15. Ottawa stability, with isobases on the Ottawa water plane.

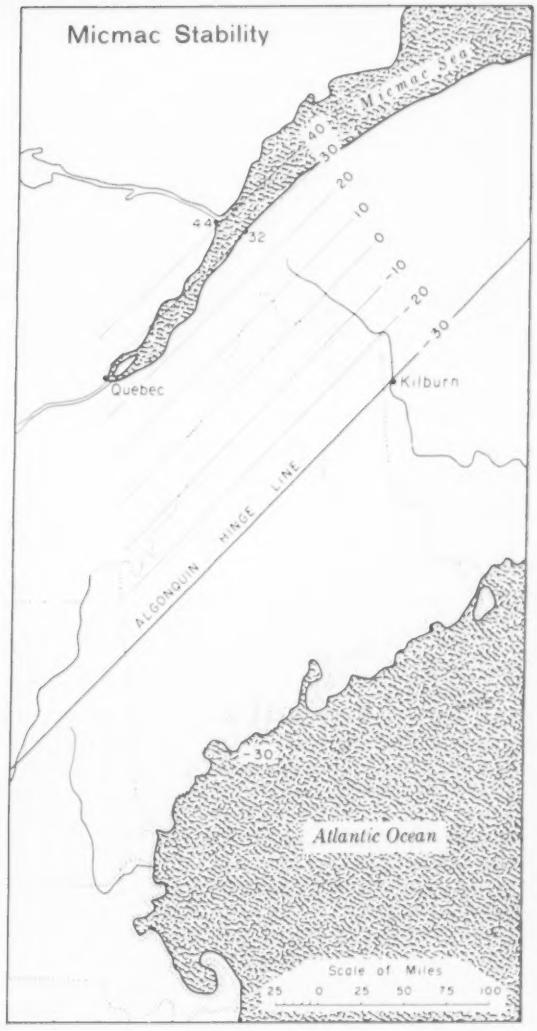

Fig. 16. Micmac stability, with isobases of late-Hudsonian upwarp on the Micmac water plane.

Stage (Fig. 15). Crustal stability followed the Algonquin uplift at some time after the ice border had melted back to positions north of the Great Lakes and out of the Ottawa lowland. This stability, perhaps coinciding with final disappearance of the ice cap in Canada, is marked by the Nipissing stage of the Great Lakes, and its marine equivalent, the Ottawa Sea, in the Ottawa, St. Lawrence, and Champlain valleys. These lake and marine stages had no association with ice. They have strong shorelines—that of the Ottawa being by far the best developed shore in the Ottawa Valley[32]—and not infrequently cut in rock along the lower St. Lawrence. It is several hundred feet below the Champlain marine limit and has elevations of 240 feet (73 m) at Ottawa, 225 feet (69 m) at Montreal, and 170 feet (52 m) at Rivière du Loup. The Ottawa water plane, tilted 2.2 feet per mile or more penetrates the northern end of the Champlain basin, where it is responsible for the highly fossiliferous condition of the deposits.

The highest beach lines at the ice-depressed center of the continent around Hudson and James bays may correlate approximately with Ottawa time. Marine submergence in James Bay reaches to within 200 miles (322 km) of the north side of Lake Superior, but scarcity of accurate measurements restricts an estimate of the highest marine evidence to the occurrence of land-locked seals in Seal Lakes of Western Ungava at about 800 feet elevation (244 m).[33] On the New England coast, as elsewhere outside the Algonquin Hinge Line, the shore of Ottawa time is submerged at approximately the 10-fathom (18.3 m) line.

9. *Early Hudsonian Uplift* (upwarp included in post-Ottawa isobases, Fig. 15). The Nipissing Great Lakes beach and all later beaches reach their southern limit of tilt at the Algonquin Hinge Line, which is the reason for assuming that this hinge line marks the outer boundary of all late and present-day uplift. Very great uplift, amounting to at least 800 feet (244 m), has affected the downwarped basin of Hudson Bay since the bay became ice-free and has left it rimmed with innumerable shorelines descending steplike to present sea level.

Hudsonian, or post-Ottawa, uplift may be divided into two stages: (1) early Hudsonian, which represents tilting from Ottawa time to time of the Micmac Sea, and (2) late Hudsonian, which represents tilting from Micmac time to present time. Excellent records are offered by the shoreline spectrum of the St. Lawrence Valley, but refinements in late history will come with future studies of Hudson Bay beaches.

Isolation of Lake Champlain from the sea took place during early Hudsonian uplift. The lake has an outlet northward, and after isolation had been established, further tilting of the basin has submerged all shorelines antedating the present shore. Hudsonian upwarp has accelerated the Connecticut River northwest of the Algonquin Hinge Line at Hanover, New Hampshire, but has retarded northward-flowing streams like Otter Creek in Vermont.

10. *Micmac Stability, and the Micmac Marine Stage* (Fig. 16). The exceptionally strong Micmac shoreline of the lower St. Lawrence Valley maintains elevations ranging from 20 to 30 feet (6.1–9.1 m) for a distance of 200 miles (322 km) along the south shore of the St. Lawrence trough, parallel in direction with the Algonquin Hinge Line. On the north side of the St. Lawrence in directions away from the hinge line, the Micmac terrace reaches 45 feet (13.7 m) or higher, evidently taking part in late stages of differential upwarp centered around Hudson Bay, where this shore may be several hundred feet above present sea level. It is generally conceded that the Micmac terrace, which the present weak shoreline in the St. Lawrence estuary cannot match in strength, represents combined effects of an important interval of crustal stability, and transgression by rising sea level—both factors giving shore processes opportunity to cut continuous sea cliffs and a broad wave-bench as far inland as the city of Quebec.

In appearance the Micmac shore resembles wave-cut parts of the present New England–Acadian shoreline, of which it may indeed be an early and uplifted phase. Projection of the limited profiles southward to the Algonquin Hinge Line makes it appear that the Micmac water plane began to tilt during a stage of sea level approximately 30 feet (9.1 m) lower than present sea level.

11. *Late Hudsonian Uplift* (isobases, Fig. 16). Late Hudsonian upwarping which has raised the Micmac Terrace and tilted it about ½ foot per mile, has continued to Present time, uplifting Hudson Bay several hundred feet. Late stages of differential rise of the land around the bay have been so great that a complete diversion of drainage has taken place in the headwaters of Ottawa River, which formerly flowed northward to Bell River and James Bay until the tilting of Grand Lake, which lies in the course of the Ottawa, opened a southerly outlet toward the St. Lawrence.[34] Successively lower deltaic deposits grading into river terraces along the lower course of Ottawa River show how the mouth of that river advanced toward the emerging trough of the St. Lawrence during Hudsonian upwarping.

The last 16 feet (5 m) rise of sea level has submerged fish weirs built by aboriginal man in Boston Harbor, which are among the oldest human records in eastern North America.[26] At or above this level, and assignable between Micmac time and present time, giant cypress stumps lie beneath the marshes on Cape Cod, representing warm climatic conditions like those in the present range of cypress in the Carolinas. Similar evidence of a postglacial temperature optimum is found in Europe. These shallowly inundated human and botanical records south of the Algonquin Hinge Line may be approximately contemporaneous with Eskimo campsites at river mouths in Hudson Bay which have been lifted 70 feet (21 m) above sea level since they were occupied.[35]

12. *Present Time and Present Sea Level* (Fig. 17). Hudson Bay and the St. Lawrence Valley have rising and extremely youthful coasts still being affected by Hudsonian upwarping, but present uplift of several feet per century is far slower than the early uplifts. At this rate it will take 15,000 years and an upwarp of 500 feet (152 m), not counteracted by rise of sea level, to drain Hudson Bay.

To what extent present earthquake activity is related to postglacial uplift is debatable. Hudson Bay is not notably seismic, although the St. Lawrence Valley and northern New York state are moderately so. No pattern of quakes follows the Algonquin Hinge Line, but points along the Hobbs Hinge Line in Connecticut and its extension into coastal New Hampshire have been centers of a number of quakes within historic time.[36] Glaciated

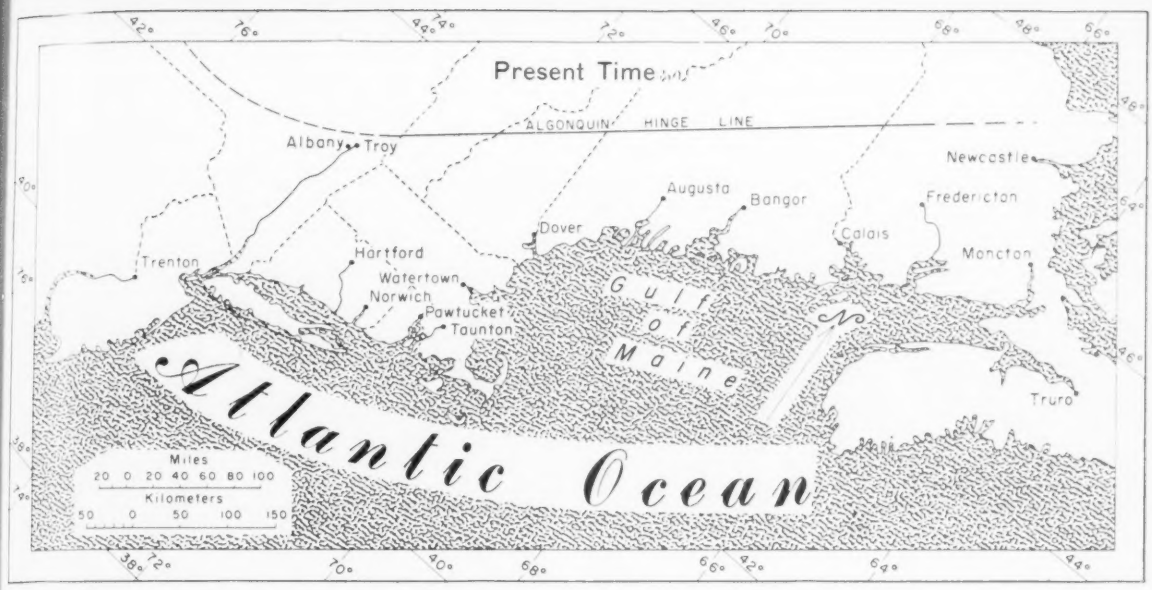

FIG. 17. Present time, marked by present sea level; tidal heads of drowned river valleys as shown.

regions, generally, are not more seismic today than unglaciated regions, and isolated cases like the Ossipee, New Hampshire, quake of 1940, originating at a depth of 30 miles (48 km), seem to relate to no recognized crustal patterns of the past or the present.

Most of New England is located on the stable side of the Algonquin Hinge Line, and the coast has suffered transgression by rising sea level of somewhat more than 100 feet (30 m) since the conclusion of Whittlesey uplift. This has driven the shore inland, beginning at the submerged coast of Champlain time, promoting the construction of offshore bars, stimulating the upward growth of tidal marshes, and drowning the channels and deltas of New England rivers which are no longer aggressively transporting bed load to the sea. Tidewater reaches inland to Albany and Troy, New York, a distance of 130 miles (209 km) along a drowned channel cut by the Hudson River in clay beds when the land stood relatively higher in the Whittlesey uplift. Tidal conditions affect the mouths of all the principal rivers of New England and New Brunswick.

Very old human cultures associated with glacial sea levels are now either submerged below present sea level, or accessible only where there are raised shores. For example, in northwestern Vermont a paleo-Indian culture, represented by an abundance of chipped stone artifacts at the elevation of the highest Champlain marine shoreline,[37] may prove to establish the presence of Man in New England in the Champlain stability. On the other hand, aboriginal occupation sites along the coastline of today must be considered Recent, for the building of Stone Age kitchen middens in New England ceased barely three centuries ago. The Titicut campsite on the Taunton River in Massachusetts, is located far inland among esker deposits of the Leverett marine stage, but precisely at present head of tide, so must date back no farther than a time when rising sea level became stabilized at the present New England-Acadian shoreline. Even so, the present shore may be many centuries old, judging by the great strength of such features as Sandy Hook, New Jersey, the claw of Cape Cod, and Nantasket Beach, Massachusetts.

Since evidence of transgression along the eastern seaboard is matched by similar evidence on all the continents, it is presumably due to continued world deglaciation. In the year 1928 tide gages of the U.S. Coast and Geodetic Survey in the Pacific and on both sides of the Atlantic began to record a rise of sea level averaging 0.02 foot (0.61 cm) per year, which has amounted to 0.4 foot (12.19 cm) in 20 years.[38] This rate of rise more than counteracts the effects of present upwarping, and if continued could raise sea level 20 feet (6 m) in the next 1000 years.

Conclusions

Glacial history has never been interpreted successfully from any other point of view than normal glacial retreat. Nor has progress been attained in reconstruction of time relationships where there is no workable method for making correlations between distant regions. Glacial deposits of eastern

North America preserve a record of orderly retirement of the southern border of the last ice sheet and evidence of successive uplifts that permit the history to be organized into a tectonic chronology like the Table of Geologic Time. To the sciences of anthropology, biogeography, and marine geology this type of chronology offers means for correlating events of postglacial history in widely distant parts of the world.

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The Involuntary Destruction of Science in the USSR

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IN the autumn of 1948 the newspapers of the world described the famous meeting of the Lenin Academy of Agriculture, the meeting in which genetics was attacked most viciously by a group which was seizing control of agricultural research in the Soviet Union. Throughout the sessions, which lasted from July 31 to August 7, the almost uninterrupted denunciations of genetics continued until, on this latter date, T. D. Lyensko, President of the Academy, announced that the Central Committee of the Communist Party had approved the line taken by the attackers. The members of the Academy received the ukase with an enthusiasm, which was described by *Pravda* (Aug. 8, 1948) as follows:

> This communication by the President aroused general enthusiasm in the members of the session. As if moved by a single impulse, all of those present rose from their seats and started a stormy, prolonged ovation in honor of the Central Committee of the Lenin-Stalin Party, in honor of the wise leader and teacher of the Soviet people, the greatest scientist of our era, Comrade Stalin.

The science of genetics was promptly outlawed and five Russian scientists found it expedient to recant.

To the enlightened citizens of the world, this procedure was as surprising as it was preposterous. The question which naturally arose was: "Why? Why should a nation which had expended so much of its revenues in supporting and developing a science, decide suddenly to destroy what it had been promoting and cherishing?" The destruction of a science—of any science—just did not make sense; it seemed particularly out of place in a nation governed by a philosophy which held that the future welfare of society depended in large part upon the advancement of science. The absurdity of the act was really so patent that its very incredibility was put to use by the defenders of the Soviets. They seized upon its senselessness as evidence that it never occurred. For example, Howard Fast,[1] in commenting on an article in the *Saturday Review of Literature* by H. J. Muller, wrote in his column in the *Daily Worker*:

> . . . It really makes one wonder what those Russians are up to and who profits through their cutting their own throats; but such a frenzy of unrestrained name-calling hardly refutes the calm and reasoned arguments put forth by Trofim Lysenko. . . .

To many non-scientists it seemed that there must really be "something" in the newer Russian stand after all. The higher authorities in Russia certainly could not be as foolish as they appeared; they could not be dismissed as morons, for all our evidence indicated the contrary. To most of us the Russians seemed to be both subtle and brilliant, for they had clearly been able to out-think our own political leaders far too often for our own comfort. What could they really be up to? How puzzling the situation was, is shown by Harrison Salisbury[2] who wrote (*New York Times* of February 27, 1949), somewhat naively:

> The American Nobel Prize winning geneticist, Professor Herman J. Muller, has charged that Lysenko's victory means the destruction of science in Russia. This seems to be an extreme view. Lysenko indicates plainly enough that the Central Committee is not nearly so much interested in theories as in results. A capable agronomist is not liable to be purged for creating a new hardy breed of spring wheat, regardless of whether he follows Morgan-Mendelian theories or those of Michurin.

Those who are equipped technically to evaluate the doctrines which displaced genetics, however, recognized at once that they were not new, but

were only a resurgence of some archaic errors which had been abandoned during the past century. Anyone acquainted with the history of biology would have no difficulty in dating them accurately. The origin of some could even be traced back to the Greeks, while others had come into prominence in the eighteenth century and had remained respectable up to seventy-five or eighty years ago. Obviously, this revival of past mistakes could not possibly represent an advance in science, and the reaction of the scientists of the free world was just what we would expect. They refused to accept the validity of the Russian claims in the absence of good, supporting, scientific data. We should mention that this was not, as some thought, an instance of a conservative and reactionary group refusing to acknowledge scientific progress. The basic question, however, still persisted. Why had the Russians destroyed a science?

A number of answers were given. Most of them were reasonable, and some were certainly valid in part. The whole picture, however, remained incomplete and obscure. Even when we combine and integrate the various answers, something still seems to be lacking. One gets the impression that something has gone wrong in the Communist world, that something has gotten out of control, that events are not proceeding according to plan. If this impression is justified, it is obviously important that we try to find out just what is happening. In this paper, our purpose is to explore briefly the whole affair, to examine the data which have become available and to try to fit them into a consistent whole.

During the twenty years which preceded the outlawing of genetics, the science had been attacked periodically by the Marxian doctrinaires and, as early as 1926, attempts had been made to foster a set of competing doctrines. In 1936 the attacks achieved sufficient prominence to reach the attention of the western geneticists, who naturally wanted to know why genetics was under fire. C. D. Darlington[3] concluded that:

> The rise of Hitler to power gave new life to the forces working against western science in general and against genetics in particular. Hitler's doctrine was founded on giving a distorted predominance to a distorted genetics. His theory assumed the permanent and unconditional, and homogeneous, genetic superiority of a particular group of people, those speaking his own language. The easy retort was obviously to repudiate genetics and put in its place a genuine Russian, proletarian, and if possible Marxist, science. For this purpose very little research was necessary: the classical personalities and achievements of Timiryazev and Michurin were there ready to hand. All that was needed was to discover a new prophet of Marxist genetics or Soviet Darwinism. The prophet was found in Trofim Dennissovitch Lysenko.
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> . . . . . .
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> A government which relies on the absence of inborn class and race differences in man as a basis of its political theory was naturally unhappy about a science of genetics which relies on the presence of such differences among plants and animals as the basis of evolution and of crop and stock improvement.

Darlington's interpretation is certainly valid, and we have in addition many other bits of evidence which substantiate his views. For example, Muller[4] stated that the Genetics Congress scheduled for 1937 was canceled because some geneticists insisted on their right to give papers on human heredity.

> This step [the cancelling of the congress] was taken only after the Party had first toyed with the idea of allowing it to be held with the omission of all papers on evolution and on human genetics in spite of the fact that many foreign geneticists had intended in such papers to attack the Nazi racist doctrine!

We also have evidence from other sources that human genetics was a dangerous subject in Russia. The attack made on the Medico-Genetic Institute of Moscow in 1936 is one example. We find additional confirmation in the acts of the Russian censors, in that the reports of the genetic debates of December 1936 were published (in the Russian edition) with all references to man expurgated, and the book itself was soon banned. Furthermore, Newman[5] stated that work on identical twins at the Maxim Gorky Institute was suddenly terminated in 1939 and nothing further was heard of the psychologists in charge of the work. To quote Muller[6] further:

> What causes the Communist officials to push Lysenkoism so strongly? To me, the answer is obvious: it is the type of mind that sees things as only black and white, yes and no, and so cannot admit the importance of *both* heredity and environment. Believing that it has found the complete answer to all the world's ills, through its particular way of manipulating environment, the Communist Party regards as a menace any concept that does not fit patly into its scheme for mankind. The genes do not fit into that concept, in its opinion, hence the existence of the genes must be denied.

It is extremely significant, of course, that genetics was the first science to be attacked. It may be that these attacks, together with their surprising success, were the first indications that science itself was vulnerable. The Marxian obscurantists must certainly have been encouraged with the outcome. As we would expect, sooner or later other sciences would also be assailed and some might be destroyed, even though they were not directly in conflict with Marxian dogma. The anti-scientific virus started its

infection in genetics, however, in a field where science conflicted with the Communist faith.

Michael Polanyi[7] offered an alternative explanation to those we have cited. He stated that, when the final authorities who control science are not scientists themselves, sooner or later quacks will flourish and ultimately dominate the field. Even with the very best intentions, those who are not scientists cannot decide scientific questions and cannot, in the last analysis, even choose between scientists and charlatans. It is only when science is free and autonomous, when enlightened scientific opinion is the court of last appeal, that imposters can be exposed as they arise. Otherwise quackery will flourish, for the plausible oversimplifications of quackery have always had a great popular appeal. Concerning the genetics controversy, Polanyi stated:

> The demonstration given here of the corruption of a branch of science caused by placing its pursuit under the direction of the State, is, I think, complete. The more so—I wish to repeat—as there is no doubt at all of the unwavering desire of the Soviet Government to advance the progress of science. It has spent large sums on laboratories, on equipment, and on personnel. Yet these subsidies, we have seen, benefited science only so long as they flowed into channels controlled by independent scientific opinion, whereas as soon as their allocation was accompanied by attempts at establishing governmental direction they exercised a violently destructive influence.

There are undoubtedly a number of other contributory factors in the Russian reaction against genetics. Genetics denies the inheritance of acquired characters, and this type of inheritance promises so much so easily that it has always been a favorite of those who want to make over mankind in a hurry. Any group of scientists who denied such inheritance was bound to be unpopular with those who held an escapist belief in the possibility of a quick reconstruction of man and his works.

We have by no means explored all the possible causes of the destruction of genetics. Soviet biology seems to be derived from a canon which included Marx, Engels, and Lenin, and those they endorsed. Lenin had blessed a nurseryman, an importer and breeder of plants, named I. V. Michurin (1855–1935), who thus achieved a high rank in the Communist Apostolic Succession. Michurin was always a staunch Lamarckian, and in his dotage he became violently anti-Mendelian. His Bolshevik record and Lenin's approbation had raised him beyond the criticism of mortals, so Michurinism is never evaluated adversely in Russia and his doctrines are regularly greeted with lavish praise. Even N. I. Vavilov, who prior to 1939 directed Russian research in genetics, dared not contradict any of Michurin's pronouncements and, as the lesser geneticists also wanted to live, any honest discussion of the basic problems of genetics was out of the question in the scientific academies of Russia. Consequently, in the "socialist competition" for position and power in the biological field the type of winner could be predicted easily. No honest scientist could ever be as good a Michurinist as those who fit their convictions to the Party line.

Any critical evaluation of the explanations we have thus far given must acknowledge that, although they may be valid as far as they go, they are certainly incomplete. They do not account for all that has happened to science in the Iron Curtain countries, and they tell us almost nothing about the growing hostility to science and to scientific standards. When we remember that such disciplines as soil science, pathology, physiology, and statistics also have been attacked and that they have been injured to such a degree that their recovery is doubtful, we must admit that more is involved in the spreading debacle than the basic conflict between modern genetics and the biology of Marx and Engels. If we are to understand what is really happening to science in Russia, we must penetrate much farther than we have into the Soviet way of life and we must not overlook the possibility that the Communists themselves do not know all that is happening and do not really understand what they are doing.

In spite of the fact that a number of our own scientists are acquainted intimately with Russian science and have studied intensely the Russian attacks on science, they have not succeeded in finding explanations of the affairs which are both complete and reasonable. This in itself suggests the existence of irrational factors, and of actions and decisions which are basically illogical. There is even evidence that the affair has grown completely out of control and that the Communists themselves are helpless and cannot stop what they have started. We now have reason to believe that the Communists are beginning at last to realize that they have injured their own strength and security but do not know how to remedy the situation.

When alogical factors begin to assume paramount importance in a situation which should be handled reasonably, we can always blame the state of affairs on historical accidents. Obviously the Russian destruction of genetics is such an accident, but to acknowledge this does not advance our un-

derstanding until we analyze and identify its causes. We must be able to recognize the significance of the important incidents in the history of the Soviets which, cumulatively, have produced an intellectual climate in which some sciences do not thrive and others actually wither and die. To list these incidents we will have to go back to the early days of Communism, back even to the Party line in biology as it was set by Marx and Engels, because the first liquidation of Russian scientists was a result of the resurrection of this line.

The hostility of Marx and Engels to scientific objectivity is still not realized generally; in fact, it has been beautifully camouflaged. Both Marx and Engels claimed to revere science and to be scientific themselves in their contributions to economics and sociology. They praised science consistently and called it the hope of mankind, but even so they denounced and misrepresented all scientific theories which conflicted in any way with their Communistic postulates. This action of the founders of Communism is only now coming to light. That Marx and Engels were both thoroughly hostile to the Darwinian concept of evolution through natural selection was concealed because they accepted the *fact* of evolution enthusiastically and they both praised Darwin highly. (Marx even wanted to dedicate *Das Kapital* to Darwin.) Moreover, they defended evolution at a time when the more conservative religious groups were attacking it. However, since the publication of the Marx-Engels correspondence in 1930, we can learn at last just what was acceptable to them in biological theory. We know now that their "line" both in evolution and in heredity is in conflict with scientific biology. Lysenko himself has pointed this out: "In his time Darwin was unable to free himself from the theoretical errors which he committed. These errors were discovered and pointed out by the Marxist classicists."

Although it is possible and even easy for us to explain how that portion of science which conflicts with a powerful orthodoxy can be outlawed, we will have to search further if we are to discover why scientific principles which are politically neutral are also denounced and suppressed. In fact, we will have to identify the conditions which determine how science develops under a totalitarian regime.

Paradoxically enough, the first signs of a drop in the quality of Russian scientists are to be found in the results of Lenin's attempts to foster science. According to his plans, the Communist state was to give science full support and train new scientists in wholesale lots. The dangers of such a procedure are obvious, even if all possible safeguards are observed. We have evidence, however, that the Communists did not recognize the dangers inherent in their program and used no safeguards whatsoever. They even made for themselves a number of unnecessary hazards in that they chose new scientists from politically "reliable" classes such as the laborers and the peasants. Of course these two classes could produce a number of good scientists, which they did. But Russia needed many thousands of first-rate scientists and, as we have learned from a number of refugees, many of the children of the intelligentsia and the professional classes were denied a university education and hence could not become professional scientists. Thus, in spite of her needs, Russia reduced the number of scientists she could obtain from just those classes which produce the majority of the scientists of the western world. Quantity Russia had, but the average quality was low, so low in fact that large numbers of the prospective scientists could not pass their university examinations.

For this difficulty, the Communists had a perfect collectivistic remedy. Cooperation was the answer. The students were divided into small groups that took their examinations in a body. They pooled their knowledge and, when a group was able to pass its examinations, the individuals who made up the group became scientists. We can now trace to those who passed their examinations cooperatively some of the horrifying examples of ignorance which some Russian scientists display. Thus it was not long before the Russian scientists were, literally, of all types, ranging from excellent to terrible, and the political authorities had a wide choice as to the kinds of scientists they could promote to positions of importance and influence. The political authorities were also uninhibited by any real scientific considerations in making their choices, for conditions in Russia are not such that the politicians prefer scientific standards to their own personal safety. In Russia the truth may be all right in its place, but it should never be allowed to become a nuisance and spoil one's career.

The outcome of the conflict between genetics and Marxian biology taught a direct personal lesson to all of the scientists in the Communist lands. It had become clear that promotion, status, and even safety did not depend upon a devoted attachment to the truth but to guessing right, to being on the winning side, to telling the political authorities just what the political authorities want to hear. The road to safety was clearly not to be found by a careful and honest interpretation of experimental data but by preserving a rigid

Communist orthodoxy, by endorsing just those doctrines which are compatible with the beliefs of the dominant clique. For example, in the field of linguistics, disaster could be avoided by agreeing "with the mighty discoveries of the greatest scientist of all time, with Stalin." But this is not all. Lesser authorities have also been canonized. Scientific orthodoxy is also set by the published work of Michurin, Lysenko, Pavlov, Williams, etc. A clever scientist thus has many guides to safety. If he is alert he may keep his job and his family will continue to eat.

The good scientists of Russia have learned their lesson, and have learned it well. The way to avoid the humiliating recantations is now clear. By paying close attention to the articles which appear in *Pravda* or *Izvestia* they can discover, without too much trouble, just what is expected of them. Those who have a sense of humor may even get a subtle revenge on the authorities who control their destinies. But in all these happenings there are most serious consequences for the Communist world. In a number of scientific fields her leaders have cut themselves off from the truth and, perhaps fortunately for the free world, they have no means for reestablishing the connections. Once the good scientists have been intimidated or disgusted, all the scientists are reduced to the same level, the level of the charlatans. Even if Stalin himself had wanted to know the truth about Mendel, he could not learn it. He could find no reason to believe what anyone would tell him.

If all the sciences in Russia had sunk to the level of those which have been injured most, the Communist regime could soon be dismissed as an unpleasant episode in the long instalments of human history; its internal weaknesses would soon reduce it to impotence and the world's worry would be over. We must recognize, however, one fact which might prevent the deterioration from spreading and becoming uniform throughout all science. There are fields such as engineering and applied physics where the results of bad science can be discovered immediately. In these fields quackery does not last long. Here, at least, if the political authorities cannot recognize good scientists they can at least discover quacks, and, by a ruthless elimination of the latter, may even maintain relatively high standards. On the other hand, the situation is very different in medicine and agriculture, for in these fields there are none of the simple tests which may allow a layman to reach a sound and discriminating judgment. In spite of quacks and cultists, patients recover and crops grow. In medicine and agriculture only honest scientists can evaluate the current practices. A large part of Russian science, however, falls somewhere between engineering and agriculture in the direct measurability of its practical achievements. In these intermediate sciences we would expect quackery to flourish inversely as the ease of identifying quacks. We certainly cannot judge all Russian science by what happens in one or two fields.

The present status of Russian science, of course, is of tremendous importance; it may even be more important for us to extrapolate the present tendencies and to estimate its future course of development. In December 1951 the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (Section L) held a symposium entitled *Soviet Science*.,[8] and this symposium has been published. I refer you to this work for as good a picture as we can give of Russian science today. The following brief summary is based mostly on the evidence cited in that work.

1) Genetics has been extirpated in Russia and its place taken by an archaic quackery.

2) Statistics has lost its basic honesty. It is now used to falsify data for propaganda purposes.[9]

3) Psychology and psychiatry are practically dead, with little chance of recovery.

4) Biology and agriculture are so permeated by quackery that nothing of importance can be expected from them.

5) Physiology, pathology, and medicine are forced into a rigid and stupid orthodoxy which contains much quackery; their future development is inhibited, but some sound practices still survive. News from Moscow (January 12, 1953) shows that the high Soviet officials no longer trust their own physicians (*Pravda*). Their suspicions, of course, are justified, as the physicians dare not use methods in medicine incompatible with "Michurin science."

6) Geology is subjected to political attacks and pure research is discouraged.

7) Astronomy includes the amusing quackery of astrobotany, or the study of plant life on the planets. Certain theories as to the origin of the solar system are forbidden, but nevertheless much excellent work is being done by Russian astronomers.

8) In chemistry, certain theories, such as resonance, are forbidden, but much good chemical research is still being done.

9) The basic philosophical background of modern physics is labeled "idealistic" and is condemned. However, in physics, many of the words are separated from their meanings so that basic research is probably not hurt by its accompanying verbiage. Russian physics is definitely good.

10) Russian mathematics is truly excellent, a science of which any country might be proud.

11) Engineering in Russia is probably adequate for all military and civilian purposes.

What of the future of Russian science? Will the quackery spread until all science is engulfed or will it be contained and ultimately wiped out, so that the Russian sciences will again become sound?

The best answers we can give to these questions cannot be better than educated guesses. We must also limit our guesses to the immediate future. We may hope that in the distant future Russia will again become an important part of the civilized world and that Russian science will again be a part of world science. The prognostications for the near future, however, are not too hopeful.

Before we undertake the perhaps gratuitous task of guessing what the future holds, we should record both the factors which are unfavorable for the recovery of Russian science and those which tend to restore it to health. This procedure should be useful even if it does not lead us to any final answers, even if our listing is very incomplete and we omit many important factors because of our limited knowledge. We really do not have very much to guide us from the past history of science, for the present situation is, in part, unprecedented. We will begin by listing the unfavorable factors. This portion of the over-all picture will be very black indeed.

The first injurious factor is the low quality of many of the professional scientists. In the early days of Communism a great many badly trained and stupid scientists were produced. These discovered that they could rise to positions of importance by keeping their science Marxian and, particularly in biology, by reviving some abandoned doctrines of the eighteenth and nineteenth centuries and presenting them as their own new discoveries. To protect themselves they then had to attack as heretics the abler, older scientists who knew what they had done. These attacks met with such a spectacular success that all the scientists of Russia were taught just what they had to do to survive, and what they had to do did not include publishing the truth as they saw it.

Second, the scientists realized that their position was precarious in fields where science conflicted with Marxian orthodoxy and, in the universities where the advance of quackery was resisted longest, good students were advised by their professors not to specialize in these sciences. The result is that now in Russia certain fields exist in which there are no honest or capable scientists. Thus some sciences cannot recover unless scientists are imported from abroad to train and educate a new generation of Russians.

Third, when an individual scientist has worked in two or more areas and when he is on the wrong side in one of them, he becomes especially vulnerable. He becomes a bad man, a bourgeois reactionary or even a Trotskyite, and he can be attacked in all fields. Thus Orbeli, who was first denounced as a follower of Mendel, was attacked a year and a half later as a bad or western physiologist. Physiology itself turned out to be vulnerable and, with the attack on physiology succeeding, the tactical positions of psychology, pathology, and the related sciences worsened rapidly. Thus quackery was able to spread from science to science.

Fourth, enough of the low-grade scientists were raised by political pressure to membership in the scientific academies to outvote the good scientists. As no dissentient minority is allowed to exist in a totalitarian country, those in the minority were forced to recant. These recantations really shocked the western world. The almost unbelievable conditions under which scientists must live in a totalitarian regime are shown by the following quotation which, incidentally, comes from a source no Communist can question. It is from Stalin himself on the occasion of the reversal of the Party line in linguistics (*Pravda,* June 20, 1950):

> The slightest criticism of the situation in Soviet linguistics, even the most timid attempts at criticism of the so-called "new teaching" [the old Party line] were persecuted and suppressed on the part of the governing circles in the field of linguistics. For a critical attitude toward the heritage of N. Ya. Marr, valuable research workers were deprived of their jobs or demoted. Workers in the field of linguistics were promoted to responsible positions, not on the basis of merit but of unqualified acknowledgement of the teaching of N. Ya. Marr.

Fifth, the basic intellectual climate of Russia is hostile to anyone who is overly fond of the truth. In all scholarly fields, the truth as such is simply ignored. In history, for example, this state of affairs is described excellently in an article by Bertram D. Wolfe,[10] entitled appropriately "Operation Rewrite":

> Histories succeed each other as if they were being consumed by a giant chain smoker, who lights the first volume of the new work with the last of the old. Historians appear, disappear and reappear; others vanish without trace.

Sixth, the stage seems to be set for the spread of Party line science into many fields which it has not yet corrupted. *Izvestia* (November 13, 1952) carried an article by A. Topchiev declaring that it is necessary to conduct large scale discussions in the various fields of biology, chemistry, geology, geography, physics, and other sciences to destroy "obsolete and reactionary theories which hinder the forward movement of science." These discussions, followed by the recantations of those on the losing side, have thus far been the final step in the triumph of the charlatans.

Finally, the Communists have developed within their culture a behavior pattern which has acquired

enough autonomy to grow out of control. The final authority in science, as we have stated, is in the hands of non-scientists and the treatment of scientists has been such that they dare tell their masters only what they believe their masters want to hear. The political authorities in Russia thus have cut themselves off from access to the truth in many scientific fields. All Russian scientists, whether stupid, intimidated, or disgusted, have been reduced to playing the roles of charlatans when they deal with the politicians. The rulers of Russia are consequently not justified in believing anything that their scientists tell them. The result, of course, is that the politicians cannot correct conditions even if they want to, even if they are positive that quackery is rampant. They may eliminate some quacks, but this will not help. Although some who rode to affluence with Lysenko in 1948 have already been liquidated, the over-all situation in the biological sciences has not improved. In medicine, we have the ludicrous spectacle of the physicians and their commissar patients living in terror of each other.

We should emphasize that these more or less autonomous behavior patterns exist in all cultures and that they frequently defy all attempts made to control them. The pattern we have described in Russia now seems to be well entrenched and able to defy even the best intentioned commissars. We have experienced these rebellious cultural patterns in our own civilization, and we cite, as an example, the custom of buying and selling spirituous liquors which persisted in spite of adverse votes and even in spite of a constitutional amendment. The silly custom of duelling also showed a surprising vitality and lasted long after it met with general disapprobation. On a more frivolous level we might mention that the custom of tipping has weathered many attempts at suppression. Today it shows no symptoms of going into a decline.

To return to a more somber plane—a very serious condition arises if a behavior pattern, which is incompatible with a healthy science, develops as an integral part of a social system. In such a society, science has little future. Feuer[11] has shown the basic hostility of the official philosophy of communism—dialectical materialism—to scientific objectivity, and hence its basic conflict with science itself. Hartung[12] has pointed out that science is an institution which interacts with and is dependent on society in many complicated ways. Science is obviously vulnerable to an inimical society, and history shows many examples of science flourishing for a time only to decay and vanish as its enclosing culture grew hostile to intellectual honesty.

So much for the unfavorable factors; they might seem to be sufficient in themselves to doom all science in Russia. We should not overlook other factors, however—factors which work in the opposite direction. Two of these may be of real importance. First, we should note that science becomes healthy when it is merely left to itself and the scientists are free from any nonscientific meddling. Scientists are able to correct any errors they may make, and indeed do so. Actually, if they had not learned to correct past mistakes, modern science itself would never have come into being. Where science is free, it tends to stay healthy. Russian mathematics is a case in point, for it is a field in which the commissars cannot interfere. Any branch of Russian science, where good scientists still remain, may recover if it is only let alone. But this process will be slow under the best conditions. In other branches, where no good scientists remain, recovery can occur only if foreign scientists are brought in as teachers for a native crop.

Second, as we have stated earlier, in engineering and atomic physics, the ease with which the end results can be tested makes them relatively free from quackery. If an atom bomb does not explode, the physicists responsible cannot save themselves by quoting Marx, Engels, and Lenin. Progress may be slower in Russian physics than in the physics of the free world, but we may be sure that it will be made.

One thing we can state definitely about Russian science—it is in a state of flux. It is changing rapidly, and seemingly it is changing in many directions. We know that our guesses as to its future need be only a temporary expedient, because before long the future will be with us and we will know just how Russian science will have developed, during the period when a Russian behavior pattern which was hostile to science got out of control.

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The Origin of Trade in Indonesia

JUSTUS M. VAN DER KROEF

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PERHAPS the most outstanding aspect of some of the so-called primitive cultures that have been studied by social scientists is the close interrelationship that exists among all sectors of human behavior. Traditionally, the religious and moral concepts of the community are closely interwoven with social organization, and these in turn interact with the political structure and with economic pursuits and production patterns. Not one segment of life can be regarded as far removed from the moral religious core of the society in question, and every significant activity of man is directly related to the overarching system of ethical values which gives a community its distinct character.

Among the peoples and cultures of Indonesia, this interrelationship comes very forcibly to the fore. Although Indonesia is now an independent, national state, its inhabitants exhibit a great variety in social institutions and mores and the degree to which they have been westernized. The high rate of illiteracy (still about 75 per cent) and the inadequate communication system, with its resulting isolation, are some of the reasons for these differences. As a result, in many areas the social structure of village society is still intact, and with it the close interrelationship among all the sectors of human behavior. In this article an attempt will be made to show that the origins of trade in many, if not most, Indonesian communities seem to be embedded in the magic-religious core of society and that, as institutions, trade and commerce cannot be understood unless they are related to this religious essence.

Social and Religious Dualism

Fundamental to an understanding of indigenous trade patterns in Indonesia is the widely prevalent dualism in social structure and religion. Where the traditions of clan ordening survive, it is usually two clans or clan units that stand in a particular social and religious antithesis toward each other. One clan supplements the other, and both satisfy each other's needs. One clan unit delivers its women to the other, and in turn receives its women from still a third clan or clan unit (asymmetric connubium). Two social groups always confront each other, not only in marriage relationships, but also in the exchange of specific goods.

An example of such an arrangement is the traditional society of the Toba-Bataks in the central part of Sumatra.[1] Here kinship is based on a system of patriarchal clans. Between two clans a supplementary relationship exists. One clan, the *hula-hula,* delivers its women in marriage to its definite opposite, called *boroe.* As far as possible the hula seeks to marry off its women into this boroe and the "ideal" marriage is that between sister's son of one clan and brother's daughter in the other. Between boroe and hula there exists an important exchange relationship, in which the boroe is regarded as the "inferior" of its hula and as dependent on the latter for both its spiritual and material well-being. From its hula, the boroe receives first of all the *sahala,* the life-giving substance which the entire social group requires. Not only through marriage is the sahala transferred to the boroe, but also through the exchange of food and gifts. This exchange pattern is of the utmost significance, for it is fundamental to an understanding of the origin of trade. Whenever members of the boroe visit the hula-hula, the latter gives them fish to eat. Fish has a symbolic and religious significance, for it is the expression of fertility, whose fruit means long life. A man about to sow his land in the Batak country eats fish, and again after he has sown, in order to bring about a bountiful harvest. The fish eaten by the boroe strengthens its sahala. The hula-hula also gives the *oelos* to its boroe. The oelos is a garment or cloth of certain specifications; it is believed to be magically charged with the sahala. Between two clans there thus exists a traditional exchange in this one commodity, and its special religious significance also comes to the fore in, for example, the case of

a married woman desirous of offspring. Where the marriage has remained barren, the husband will visit the hula-hula of his wife and request that the hula give him the *oelos ni tondi* (the cloth that brings fertility and the life spirit), which is certain to make the wife pregnant. Also, land may be given by the hula to its boroe, and the land thus transferred carries with it the same concept of fertility and bountifulness associated with fish and oelos; for the land produces the food from which the community draws its sustenance, and by partaking of this food the boroe shares in the same physical substance of which the members of the hula are "made."

In return the boroe gives its hula-hula specified gifts, the so-called *piso,* or *pisopiso.*[2] These traditionally included first of all knives or sabers, although these are rarely given nowadays; at present metal objects, including minted coins and gold are generally substituted. The expression often used in the bestowal of the piso (knife) gift is "*piso hadjodjahan*"; i.e., "a knife on which one can lean." The piso is given by the boroe not only by way of exchange for the oelos, but also in other forms, such as food, as a kind of material assistance to the hula-hula when it needs it. For both the boroe and the hula-hula can exchange rice and fruit in place of piso and oelos, respectively. The hula-hula, instead of giving an oelos, or similar gift, can also bestow cattle and livestock on its boroe, and the hula hopes that the cattle will multiply in fertility along with the recipient boroe. It should be remembered, however, that all such gifts are substitutes, and that the pattern of exchange as it is understood among the Batak is that of oelos and piso, garment and knife. The religious and symbolic significance of these two objects will be demonstrated.

Marriage and Trade Relationships

It is remarkable how this kind of trading pattern finds its counterpart among the various peoples of the Indonesian archipelago. For example, on the eastern part of the island of Sumba in eastern Indonesia, many hundreds of miles away from the land of the Toba Bataks, one encounters the same arrangement.[3] Here the patriarchal clans or clan units, called *kabisu,* also have their definite opposites for purposes of trade and marriage. One kabisu delivers the women, the other "receives" (i.e., marries) them, and a third kabisu sends its women in marriage to the first. But at all times the dualistic element in the social order obtrudes: always two kabisu exist, one that receives, the other that gives; the same pattern of cross-cousin marriage emerges between the various clans. With this marriage relationship a trade relationship is united, which in earlier days probably had an entirely ritualistic character. The kabisu that sends its women in marriage to its opposite is also the giver of garments and cloth, sometimes also pigs (traditionally raised by women) and ivory bracelets. The kabisu that sends its males in marriage to its accepted clan opposite, sends first of all knives and sabers, or *parangs,* or sometimes horses, metal earrings, or minted coins. Again the principle that is followed here is the "meeting" and exchange of cloth and knife, respectively, the female and the male element in the clan relationship. In more modern times the range of objects given on both sides has been greatly extended, but the antithetical basis of the exchange is still preserved.

This relationship between opposite clans is irreversible—among the Bataks it is impossible for the boroe to give land to its hula-hula, as this would be sacrilege; nor is the marriage of parallel cousins allowed, as this would be incest. Or, as the Batak puts it, "Water cannot return to its source." The existing antithesis is religiously sanctioned and only through the proper "meeting" of the opposite units is the religious order preserved and strengthened. It should also be noted that the union of the appropriate antitheses has a totemistic character. In marriage, as well as in trade, the totem of the clan of the husband and male (women-receiving and men-sending clan) is joined with the totem of the clan of the wife and female (women-sending and men-receiving clan), symbolizing the cosmic unity of the human group through their mutual antitheses. Two totem "streams," so to speak, meet, each going in an opposite direction, just as in the well-known case of the *kula* of the Trobrianders in Melanesia, studied by Malinowski. The two antithetical commodities exchanged in the kula (bracelets and necklaces, respectively) are also said to have "married" when they are exchanged.[4] And the same can be said for the goods exchanged by the kabisu in east Sumba.

In Indonesia the knife, kris, or saber and the cloth or garment appear over and over as symbols of male and female, respectively, and with them traces of antithetical clan structure, with a preference for cross-cousin marriage, have been noted for virtually all the peoples of the archipelago. The metal knife or kris is a typical implement of the male, associated with hunting, cattle breeding, meat cutting, and so on. And over a wide area, too, metal or metal objects have a magic quality, because they have hardness and durability.[5] The hardness, so it is believed, reflects great strength, magic strength—not even fire can touch it. The owner of this hard-

ness becomes himself infused with magic strength, thus drawing support from the knife; hence the expression "a knife on which one can lean" among the Bataks, and hence the belief, still evident among the Javanese, for example, that a kris has a magic quality that can make its owner fearless and invincible. Similarly the cloth or garment in Java has, when it is prepared in the ancient *batik* or dye, a sacred property; the traditional batik sarong worn by Indonesian women is thus something more than a mere article of clothing, and its purchase is traditionally more than a mere economic transaction.

Another aspect of trade on Sumba needs to be mentioned because of its connection with the fundamental religious antithesis that underlies most traditional commercial transactions in Indonesia. This is the *pahamboer,* or "meeting," involving an exchange on an extra-clan basis between two groups of people, one from the coastal area and one from the mountain region. An agreement is reached between a coastal dweller and a mountain inhabitant that on a specified day they will meet, together with a fixed number of fellow-villagers each, for the purpose of trade on a barter basis. The people from the coast bring sea products, fish, coconuts, and clothing, those from the mountains bring food or sometimes crockery. The number of participants must be the same on each side, so that there is no risk of having to take back home what was originally brought for trade. A fixed date is set and the trade or exchange takes place.[6]

This aspect of trade is important for two reasons. First the pahamboer is surrounded by the old antithesis of two, although in this case not necessarily related, groups; although the action is trade, the term given to the transaction is "meeting." One would expect a term that would indicate the commercial character of the process; instead the element of coming together, of "meeting," is emphasized.[7] The same principle is, as has been shown, inherent in the exchange of male and female goods among the kabisu; here the totems of two opposite clans meet and are fused into a higher, religious unity. Proof of the antithetical character of pahamboer is further strengthened by a look at the similar dualism in society and religion in the island of Bali. In the pahamboer it is the sea people and the mountain people who come together. In the Balinese world order it is exactly this dualism between the mountain region and the sea that determines the entire sacred character of the social order and its religious function, reflected in village society, social classes, and cultural life.[8] Again the sacred antithetical element that underlies the trade transaction of the pahamboer, which has similar manifestations in many regions of the Indonesian archipelago, is evident.

It may seem scientifically unwarranted to stress similarities in such widely separated cultures as those of the Toba Bataks and the inhabitants of Sumba, or to emphasize identical patterns of antithetical social ordening for many, if not most, peoples in the Indonesian archipelago. The fact is that the evidence thus far amassed points undoubtedly to the existence of a clan dualism, or to its distinctive traces, with a corresponding exogamous (usually cross-cousin) marriage pattern and a religious-commercial supplementary function of clans or clan units in such widely scattered areas as the central part of Timor, Tanimbar, Seran, Wetar, Amboyna—indeed, in virtually all Eastern Indonesia except for Sulawesi (although among the Toradjas of central Sulawesi traces of it exist—in Sumatra, where even the Minangkabau society shows remains of it; in Borneo among many Daya communities; and finally even in Java.[9] Amboyna, for example, still exhibits the remnants of the ancient antithetical dualism in the structure of its village society. The village in Amboyna is divided into two parts; every part is not only a social unit but a cosmic classification category comprising all objects and events in the world around the villager. A list could be set up classifying all objects and characteristics associated with each of the two divisions:[10]

Left	Right
Female	Male
Coast or seaside	Land or mountainside
Below	Above
Earth	Heaven or sky
Spiritual	Worldly
Downwards	Upwards
Peel	Pit
Exterior	Interior
Behind	In front
West	East
Younger brother	Older brother
New	Old

The two divisions in the village are exogamous: marriage within one's own division is prohibited. This is a clear indication of orginal clan structure, although the clan as such has disappeared and in its place has come the closed village unit. The antithetical character of this ordening is of course quite apparent. In Java the ancient dualism has been further subdivided into a quadruple social division, also mutually complimentary and in time calling into existence an entire system of correspondences in which every color scheme, object of trade, profession, and household feature has its definite place.[11]

To be sure, the minor details of this great anti-

thesis may differ, but fundamental to all such communities is the comprehensive dualism in the structure of their society, religiously symbolized and sanctioned, and dependent upon the complementary function of the social units in marriage and economic pursuit. It is the universality of this dualistic element in Indonesian society that is perhaps its unique characteristic; it is also the key to an understanding of the origin and function of its trade.

Before analyzing the religious dualism in Indonesian society as it relates to trade, it is essential that some attention be paid to the potlatch theory, which has been offered as an explanation of the dualistic trade pattern in many societies beyond Indonesia. Briefly stated, this theory as developed by van Ossenbruggen, is as follows.[12]

The cloth and the knife, which recur over and over as symbols of a marriage and trade relationship, are not only representations of the female and male elements in society, but also of the one-time military supremacy of one clan over another. In Indonesia generally it is undoubtedly true that the woman-giving clan—for example the hula-hula among the Batak—is believed to be superior to the woman-receiving clan, the boroe. The latter provides the males for the marriage and sends out "male" gifts, the pisopiso. This sending of the piso (traditionally knives and sabers) is interpreted as symbolizing the surrender of the boroe to the superior hula-hula, "a putting down of the weapons by the vanquished tribe at the feet of the victor." It is quite possible that the relationship between hula-hula and boroe was not always a friendly one, and other studies of similar clan antitheses in Indonesia show that a spirit of enmity sometimes still lingers between the woman-sending, superior clan and the woman-receiving inferior clan. The enormous respect and awe of the boroe for its hula, even today, is perhaps a survival of this. According to this theory, the piso gift is therefore, in its original form, a symbol of surrender, given by the defeated to the victorious clan. Although in recent times actual knives or krisses are rarely given, the substitute gifts (metal, money, rice, or fruit) still have the name and symbolic significance of the pisopiso. The trade that thus develops arises out of a traditional enmity between two originally hostile groups, in which the victor perhaps tried to pacify and to bind the vanquished closer together for the sake of future peace and harmony by giving—as among the Bataks—land, cloth, and cattle, or food, all supposed sources of prosperity and fertility for the defeated group.

Out of this exchange arises the potlatch tradition, also characteristic of many peoples from the North American continent to Melanesia. Among certain North American and Melanesian clans, tribes, phratries, or other social units a most elaborate and excessively generous exchange of goods often takes place; blankets, shields, or bracelets by the hundreds if not thousands are given away, thrown away, or even destroyed with reckless abandon, each tribe trying to outdo the other. Elaborate meals are held, and hour-long speeches by chiefs are given, every one a challenge, designed to best the other. "It is, as it were, a waging of war by means of destroying or giving away various commodities;" hence, among the Tlingits of North America the potlatch is a "war dance," and the lance, or knife, on a stick as among the Kwakiutl, is its symbol.[13] Yet the purpose of the potlatch among the Tlingits, like the purpose of the clan trade among the Bataks and other Indonesian peoples, is the strengthening of the spirit of the collective soul, the life force of the community. All this could perhaps point to a rudimentary potlatch character of the dual Indonesian trade pattern. Further proof of the theory might conceivably be derived from the trading tradition among certain Toradjas of Sulawesi (Celebes). Within the village society there is virtual communism—every villager can obtain someone else's property. It is a different matter with persons of a neighboring though related village. These are not allowed to take property away free. In the case of such a Toradja who wants something, the customary procedure is to build up a pattern of mutual obligation. First, the Toradja in question bestows a gift on the owner of the object he desires. The latter is now under an obligation to give something of equal, and more often of even greater, value; not to do so would be an admission of inferiority. Thus a whole process of exchange can be set into motion, one gift forcing a countergift. In certain circumstances "this can lead to a contest in generosity and liberality, which can work in a very uneconomic manner." It is the element of trying to outdo each other in bestowing gifts that attracts our attention here; this element is basic to the entire potlatch process.[14]

Thus it would seem that the continuous exchange of specified goods between clans or clan units in Indonesia, carrying with it the possible existence of an ancient pattern of hostility between the clans and the tradition of the "surrender" of one to the other, is a rudimentary potlatch. Interesting as this theory is, it does not, unfortunately, account for all the facts. For one thing, it places too much emphasis on the giving of weapons as a symbol of sur-

render, and ignores the importance of the cloth gifts as symbols of fertility. The exchange of cloth and knife is not merely dictated by an ancient enmity or a desire to best the other clan in generosity. Cloth and knife are symbolic of female and male functions in society, which find their reflection in the carefully arranged marriage relationship between the clans, in which the traditional male element joins the accepted female element, both merging in a higher cosmic unity. This unity is constantly emphasized in the ritual, totems, and legends of most Indonesian clans. The potlatch theory does not seem to make much of a provision for this, unless one would wish to argue that the religious and social antithesis between the clans is but a later addition to the culture pattern of the group, a rationalization that came into existence, perhaps, after the potlatch process was established. Proof for such an argument, however, is altogether lacking, at least in Indonesia. Finally, it should be noted that the Toradjas are one of the few peoples in Indonesia with imperfectly developed clan dualism.

Religious Symbolism in Trade

The explanation of the trade antithesis lies elsewhere, namely, in the religious beliefs of the Indonesian clan societies. Although religious life and symbolism may vary in detail in these societies, again, most if not all, seem to subscribe to one fundamental sacral principle—the existence of two antithetical forces, which confront but also constantly merge and supplement each other in a higher sacred unity. In religious life this antithesis expresses itself in the opposition of deities of heaven and earth, and also in the dualism of male and female, or rather of the patriarchal and the matriarchal principles of life in the community; hence, in many areas, such as in certain parts of Java, one finds the belief in the descent of an entire village society from a single pair of ancestors, man and wife, who in turn descend from the male and female principles of the universe—i.e., the gods. Hence also the repeated appearance of deities or spirits, who are completely identified with male and female, earth and water, East and West, upper and under world. An example is the existence of the two ancient Batak spirits, Boras pati ni tano and Boroe saniang naga, who are personified forces of nature.[25] The first of these is male, the protector of fertility, who is invoked when a village is founded or a house is built and is associated with the earth.

The second is female, who often appears as a snake; all that has to do with water and its resources is connected with her. Most of the other gods of the Bataks appear to be of Hindu origin; perhaps only the earth god and the water goddess, the male and the female, seem to be original and unique in their society, as symbols of the great antithesis. Again, in the Fialarang myth of the Timorese in Eastern Indonesia, the antithesis reappears in the creation story of two original beings, a female earth and a male sky, out of which the human species and the universe have developed.[16] On the island of Bali it is mountainside and seaside, with gods and demons representing the upper world (mountains) and the nether world (sea), that influence the structure of religious beliefs as well as the social organization. One result of the antithesis is a magically sanctioned dualism in Balinese village society and a "male" and "female" division in the production of the rice on the communal fields.[17] Among the Ngadju Daya of Kalimantan (Borneo), the antithesis is represented by the two principal divine manifestations: the male Mahatala, symbolized as a hornbill, and master of the upper world, and the female Djata, represented as a watersnake and ruler of the under world. The entire cosmic outlook of the Ngadju is determined by his belief in the constant interaction and unity of these two divine principles; God to him is the oneness of these two divine representations: "The complete Godhead is watersnake and hornbill, Upper World and Under World, male and female, sun and moon, the holy lance and the holy cloth. . . ."[18] Again the appearance of the lance or knife and the cloth is not accidental. They are, as we have seen, the magic symbols of the traditional antithesis, the dualistic elements the interaction and subsequent unity of which are basic to the stability of the universe. In Minangkabau, in Java, in Sumba, even among the Papuas of New Guinea, the traces of this "dualistic monism" are apparent, in religion, in social organization, or in trade.[19]

It would appear, then, that the traditional exchange of gifts, fundamental to an understanding of the trade between clans or clan units in Indonesia, cannot be separated from the religious-cosmic point of view of the community in which the trade takes place. Elements of quality, cost price, profit, loss, or other economic rationalizations do not traditionally enter into the transactions. Trade is a sacred act, a ritual that satisfies first of all a moral-religious need. For it must be understood that the divine order, with its dualistic character, requires constant "rejuvenation"; i.e., the community must constantly repeat the processes of merging, "meeting," and fusion of the traditional antithetical elements, by proper marriage relations, by religious and totemistic ceremonies, and by

trade.[20] Only in this way, in the belief of the Indonesian, can the magic qualities of the universe be kept in balance and the continuity of the family and of the village be religiously assured.

From this, I think, it also follows that any economic improvement scheme, conceived along Western lines, such as those of the Point Four agencies, must reckon with the religious element in the economic want-creating process. A rationalized commercial life is alien to Indonesian tradition; should one wish to establish it, one will have to attack also the religious basis of society. For the Indonesian it is therefore not so much a question of learning better techniques or of acquiring unlimited wants for modern consumer goods as a question of espousing new cultural values, in which the adoption of the amoral orientation of Western economic theory and enterprise is the essential component.

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WHEN I LOOK UP

When I look up into the stars,
Into the vast and velvet dark,
Gaze on black wonder of the sky,
Immense and stark,

I hear the winds beyond the dusk
That play through heaven like a lute,
Above the mountains of the clouds,
And I am mute,

And dumb and shaken by the wide
Tremendous worlds of silver light,
And I am one with boundless realms
Of stellar night. . . .

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The Teaching of Limnology in the United States*

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The author, associate professor of zoology at Indiana University, has carried on research in widely separated areas. After receiving a Ph.D. degree from the University of Wisconsin in 1940, Dr. Frey spent five years as aquatic biologist with the U.S. Wildlife Service in Washington, Oregon, and Idaho, and in oyster research in the Virginia-Maryland area. Work with the U.S. Naval Medical Research included studies of fresh water areas in island groups—Mariana, Palau, Admiralty, and Yap. This was followed by a survey of war damage to fisheries in the Philippines. From 1946 to 1950 Dr. Frey taught limnology at the University of North Carolina.

LIMNOLOGY is properly the comprehensive and comparative study of all inland waters, regardless of their chemical content, temperature, or other characteristics. There are many different categories of such waters, but the most important in terms of their occurrence and direct relation to man are rivers, lakes, ponds, and reservoirs. Less important types would include hot springs, subterranean waters, bog waters, tree hole puddles, and temporary lakes and ponds in endorheic regions. The limnologist is usually first of all a biologist and only secondarily a chemist, physicist, geologist, meteorologist, and/or hydrologist; but the field is so broad and diversified that a fair number of the currently more than 1100 members of the American Society of Limnology and Oceanography are specialists in one of the physical sciences and only secondarily are biologists. Yet the ultimate goal of limnology is the understanding of the processes relating to the production of organisms in the water and by the water, and the differences between waters of the same general type. All processes—physical, chemical, and biotic—must be properly evaluated and integrated in order to arrive at acceptable conclusions. Stephen A. Forbes in 1887 emphasized the necessity for comprehensive studies in the following words:

> If one wishes to become acquainted with the black bass, for example, he will learn but little if he limits himself to that species. He must evidently study also the species upon which it depends for its existence, and the various conditions upon which these depend. He must likewise study the species with which it comes in competition, and the entire system of conditions affecting their prosperity; and by the time he has studied all these sufficiently he will find that he has run through the whole complicated mechanism of the aquatic life of the locality, both animal and vegetable, of which his species forms but a single element.

Too often the desirability of, and even necessity for, comprehensive studies is lost track of.

Limnology is considered to have had its real beginnings with the numerous and careful studies of Forel on Lake Geneva, Switzerland, in the late 1800s (Berg). With a few notable exceptions most of the centers of limnological research since that time have been established in the lake districts of Europe, Siberia, Japan, and North America. Work on lakes has been more intense than on other types of waters, and undoubtedly the limnological processes here are better understood than elsewhere. All the books on limnology that have been suitable as texts have dealt primarily with lake limnology. (The recent semipopular book by Macan and Worthington attempts to give a more balanced treatment of rivers and lakes, both their pure and applied aspects.) As a result of this emphasis in the textbooks, most limnology courses likewise emphasize lakes, and the beginning student often gets the erroneous impression that limnology is the study of lakes alone. To help correct this condition one of the real present needs in the field of limnology is a good summary of the current status of our understanding of the limnology of rivers, reservoirs, and ponds.

In 1930 J. G. Needham, reporting for a subcommittee within the National Research Council, listed 16 institutions in the United States and Canada offering courses in limnology. At the present time in the United States alone limnology is known to be taught at 66 separate locations, including eight

* Contribution No. 516 from the Department of Zoology, Indiana University, Bloomington. This paper was presented as part of a symposium "Teaching of Ecology in Urban Areas," sponsored jointly by the Ecological Society of America and the Botanical Society of America at Cornell, September 1952.

summer biological stations (Table 1). Moreover, the number of institutions in Canada offering courses in limnology is known to be much greater than the two listed in the 1930 report, although no attempt was made to determine their actual number. This is a remarkable growth within the past 22 years, and it is worth our attention to examine the present status of limnology in the United States as a guide to the problems involved in teaching the subject.

The geographic distribution of limnology in the United States is not correlated appreciably with the occurrence of natural lakes. Only ten of the states do not give some course in limnology; five of these, however, offer work in ichthyology, fishery biology, or fish management. Only the Great Plains and the Great Basin are largely without courses in limnology, although a course has been given at the University of Kansas for many years, and more recently a course has been started at the University of Nevada. The latter location is reported to have quite a variety of both lotic and lenitic habitats within a radius of 50 miles. The rather numerous courses in the Texas-Oklahoma region depend primarily on reservoirs for field work and demonstration of principles.

The distribution of limnology courses is determined primarily by the location of the large, state-supported schools, both the liberal arts schools and those technical schools that have set up programs in game and fish management. Approximately 80 per cent of all limnology courses in the United States are given at schools of this general description.

Two additional factors have helped determine the location of limnology courses:

1. The interest, drive, and activity of *men* trained in limnology as they have become located away from their alma maters. Several of these have been able to establish limnology courses at some of the smaller schools, and others are maintaining their research interests in limnology, even though they have been unsuccessful in setting up a course in limnology at a particular institution. In some instances, the research activities of these men have stimulated capable students to enter the field of limnology.

2. The *geographic factor* where it is particularly favorable has in a few instances influenced or at least facilitated the setting up of a course in limnology, especially at some smaller institutions, and in other instances where it is unfavorable has probably helped discourage establishing such a course.

Limnology is a specialized study, requiring considerable background training on the part of the

Locations where limnology is taught in the United States, 1952.

student in the supporting sciences of biology, chemistry, physics, geology, and mathematics. For this reason courses in limnology are usually given at the advanced undergraduate-graduate level, frequently at the graduate level alone, and only in twelve reported instances at the undergraduate level exclusively. Students are usually required to have had an extensive training in other science courses before taking limnology. Sometimes only general zoology or biology is required, but more frequently several courses in zoology, plus botany, chemistry, and physics may be required. Naturally those courses offered at the graduate level generally have the more stringent prerequisites.

Such restrictions based on prerequisites limit the enrollment. Reported average enrollment in limnology courses varies from 3 to 60, with a mean of approximately 10. The largest enrollments occur at Wisconsin and Michigan State, where the elementary courses are offered every year. Each year approximately 750 students in the United States are exposed to some sort of organized course in the subject under discussion; usually these courses are designated limnology, sometimes hydrobiology, and less frequently aquatic biology. In quite a number of instances a particular course is offered only in alternate years, in an attempt to increase enrollment.

Limnology as it is now taught in the United States tends to be restricted to the larger schools, especially the state-supported schools, for three obvious reasons:

1. A *large student body* is required to maintain sufficient enrollment in such a specialized course, unless the course is given at the cultural level with a minimum of field and laboratory work. The land-grant technical schools of the various states and the combined technical and liberal arts schools of the Middle West have an advantage as regards

TABLE 1

LOCATION OF LIMNOLOGY COURSES IN THE UNITED STATES

State	School	Location	Highest advanced degree offered with limnology as thesis subject
ALABAMA	Alabama Polytechnic Institute	Auburn	None
ARIZONA	University of Arizona*	Tucson	
ARKANSAS	Arkansas A & M College	Monticello	None
	University of Arkansas	Fayetteville	Master's
CALIFORNIA	Chico State College†	Chico	
	Humboldt State College	Arcata	None
	San Diego State College	San Diego	Master's
	San Francisco State College*	San Francisco	
	San Jose State College	San Jose	Master's
	Stanford University	Stanford	Ph.D.
	University of California*‡	Berkeley	"
	University of California*	Los Angeles	
COLORADO	Colorado A & M College	Fort Collins	Master's
	University of Colorado	Boulder	Ph.D.
CONNECTICUT	Yale University	New Haven	"
FLORIDA	Florida State University	Tallahassee	Master's
	University of Florida	Gainesville	Ph.D.
	University of Miami	Coral Gables	Master's
GEORGIA	University of Georgia	Athens	"
IDAHO	University of Idaho	Moscow	"
ILLINOIS	St. Procopius College*	Lisle	
	Southern Illinois University	Carbondale	Master's
	University of Illinois	Urbana	Ph.D.
INDIANA	Earlham College Biological Station	Dewart Lake	None
	Indiana University	Bloomington	Ph.D.
	Notre Dame University	Notre Dame	"
IOWA	Iowa State College	Ames	"
	Iowa Lakeside Laboratory	Lake Okoboji	(Master's)
KANSAS	University of Kansas	Lawrence	Ph.D.
KENTUCKY	University of Kentucky*†	Lexington	
	University of Louisville	Louisville	Master's
LOUISIANA	Louisiana Polytechnic Institute*	Ruston	
	Loyola University	New Orleans	None
	Tulane University	New Orleans	Master's
MAINE	University of Maine*	Orono	
MARYLAND	University of Maryland	College Park	Ph.D.
MASSACHUSETTS	Harvard University	Cambridge	"
	University of Massachusetts	Amherst	Master's
MICHIGAN	Michigan State College	East Lansing	Ph.D.
	University of Michigan	Ann Arbor	"
	University of Michigan Biological Station	Douglas Lake	(Ph.D.)
MINNESOTA	University of Minnesota Biological Station	Lake Itasca	(Ph.D.)
MISSISSIPPI	Mississippi State College	State College	Master's
	University of Mississippi	University	"
MISSOURI	University of Missouri	Columbia	Ph.D.
MONTANA	College of Great Falls§	Great Falls	
	Montana State College	Bozeman	Master's
	Montana State University Biological Station	Flathead Lake	(Master's)
NEBRASKA	University of Nebraska*	Lincoln	
NEVADA	University of Nevada	Reno	Master's
NEW HAMPSHIRE	University of New Hampshire	Durham	"
NEW JERSEY	Rutgers University	New Brunswick	Ph.D.
NEW MEXICO	University of New Mexico	Albuquerque	"
NEW YORK	Cornell University	Ithaca	"
	University of Buffalo	Buffalo	Master's
	Vassar College	Poughkeepsie	"
NORTH CAROLINA	North Carolina State College	Raleigh	Ph.D.
	University of North Carolina	Chapel Hill	"
OHIO	Bowling Green State University	Bowling Green	None
	College of Steubenville	Steubenville	"
	Franz Theodore Stone Laboratory of Ohio State University	Put-in-Bay	(Ph.D.)
	Kent State University	Kent	Master's
	Youngstown College	Youngstown	None

TABLE 1—(*Continued*)

State	School	Location	Highest advanced degree offered with limnology as thesis subject
OKLAHOMA	Oklahoma A & M College	Stillwater	Ph.D.
	University of Oklahoma	Norman	Ph.D.
	University of Tulsa†	Tulsa	
OREGON	Oregon State College*	Corvallis	
	University of Oregon	Eugene	None
PENNSYLVANIA	Duquesne University§	Pittsburgh	
	Pennsylvania State College*†	State College	
	University of Pittsburgh Biological Station	Lake Pymantuning	(Ph.D.)
RHODE ISLAND	University of Rhode Island*	Kingston	
SOUTH DAKOTA	South Dakota State College*	Brookings	
TENNESSEE	University of Tennessee*	Knoxville	
	Vanderbilt University	Nashville	Ph.D.
TEXAS	A & M College of Texas	College Station	Master's
	North Texas State College	Denton	"
	Sam Houston State College*	Huntsville	
	University of Texas*†	Austin	
UTAH	Brigham Young University	Provo	"
	University of Utah	Salt Lake City	Ph.D.
	Utah State Agricultural College	Logan	None
VIRGINIA	College of William and Mary§	Williamsburg	Master's
	University of Virginia Biological Station	Mountain Lake	None
	Virginia Polytechnic Institute*†	Blacksburg	
WASHINGTON	State College of Washington†	Pullman	
	University of Washington	Seattle	Ph.D.
WISCONSIN	University of Wisconsin	Madison	"
WYOMING	University of Wyoming	Laramie	Master's

* These schools give courses in ichthyology, fishery biology, or fish management, but not in limnology; the list of these schools is admittedly incomplete.
† These schools have recently discontinued instruction in limnology.
‡ Although no courses in limnology are offered, advanced degrees can be earned with limnology as a specialty.
§ The information listed has not been confirmed.

enrollment, in that a fair number of students are interested in limnology for various practical reasons, for example, fish management or sanitary engineering. Limnology is frequently a required course for students specializing in these technical subjects. It is significant that, at all schools except one, other courses in aquatics and ecology are given besides limnology. These include courses in various phases of ecology, algae, aquatic plants, ichthyology, fish management, fishery biology, biogeography, stream pollution, plankton, aquatic insects, and various field courses. Hence, limnology is almost invariably just one element in a diversified program in ecology and field studies, and a student can receive a fairly broad training in these fields.

2. A fairly *large biology staff* is required to free a man from the duties of teaching such courses as embryology, invertebrates, and comparative anatomy, which are usually considered more fundamental in the training of the general biologist and of the premedical student. It should be noted that nearly all the present teachers of limnology have had their basic training in zoology. An interesting exception is at the University of Massachusetts, where five separate departments cooperate in giving the course. This again illustrates the broad scope of the subject.

3. Considerable *money* is required for the purchase and maintenance of the hand-made equipment and instruments needed in carrying on field studies and laboratory analyses. Many of these items are too prohibitive in cost to be acquired only for class demonstration, but if they can also be used in the research activities of staff members and graduate students, the schools are much more likely to purchase them. Acquisition of these items is frequently aided by cooperative research programs between the schools and the state conservation departments.

At any institution various problems arise in the teaching of limnology, and the nature of these problems is in part related to geographic location. No single school can expect to have the entire gamut of inland waters close enough at hand for convenient instruction and research purposes; Washington and Oregon probably come as close to this ideal as any places in the country. Different locations have different problems: Oklahoma, Texas, and Kansas necessarily work almost exclusively on reservoirs; permanent streams are lacking close to Stanford, San Diego, and Miami; hard-bottom

Long Lake, west of Boulder, Colorado, at an altitude of approx. 11,000 feet. This lake might be considered typical of the many alpine lakes in the Rocky Mountain Region. (Photo by R. W. Pennak, University of Colorado.)

streams and thermally stratified lakes are not available close to New Orleans, whereas eutrophic lakes and streams with moderate to weak gradient are difficult to reach from the Flathead Lake Station in Montana; most schools in the northern tier of states cannot satisfactorily demonstrate thermal and chemical stratification in lakes during the regular school year, and Michigan State, therefore, concentrates its field work on the effects of ice and snow cover and other aspects of winter limnology. Because of the annual cycles that occur in waters, summer is probably the best time to teach limnology, although the geographic limitations of the particular field stations still hold. The Franz Theodore Stone Laboratory on Lake Erie is well situated for the study of many aspects of limnology, but its classes must repair to the mainland for direct

Rutter's Pond—a 4½-acre artificial pond in central Oklahoma with an annual catch of fish by hook and line of 800 pounds per year. In many parts of the United States lakes and ponds must be provided artificially by man. (Photo by Lee Stevens. Furnished by W. I. Irwin, Oklahoma A & M College.)

observations on streams and stratified lakes. It should be possible, however, regardless of location, to teach the *principles* of the subject in lecture and to illustrate a satisfactory number of these principles by studies on the particular waters that are available.

Closely associated with the variety of aquatic habitats available for study is the matter of textbooks and literature. It has already been pointed out that as a result of a combination of circumstances all suitable textbooks stress the limnology of natural lakes. Persons working on the limnology of reservoirs in Texas, Oklahoma, and Alabama do not find current limnology texts particularly applicable to their situations. They feel a strong need for a book summarizing the limnology of reservoirs.

Courses specifically in stream limnology are given at Colorado and Indiana, although a number of other schools, such as New Mexico and Utah, stress stream limnology because of their geographic location. Here, in particular, the time is ripe for someone with the necessary time and energy to sift through the vast number of papers on stream limnology in a considerable variety of languages and to boil the various ideas down to their essentials to determine what generally applicable principles can be established. Such an undertaking would serve as a much needed stimulus to further work on streams.

Farm ponds, which are widely distributed over the United States, serve a variety of purposes, including the production of fish for the food and pleasure of the landowner and his friends. Yet the limnology of these small bodies of water and the factors controlling the production of fish in them are inadequately understood. In these waters, probably even more so than in lakes, emphasis in the United States has been on the fish management aspects of the subject.

This emphasis on the applied aspects of aquatic studies in the United States is attested to by the fact that at least seventeen schools in the country offer courses in fishery biology, fish management, or ichthyology without at the same time offering any course specifically in limnology. Undoubtedly a certain amount of limnology is given in at least some of these courses, but one could scarcely expect this to substitute for a regular intensive course in the subject.

Another problem in the teaching of limnology is that of *field work*, and the *equipment* and *transportation* involved. It is quite generally agreed by those who teach limnology that field work is essential, although there are a few exceptions.

Wisconsin does not feel that field work is essential in the undergraduate course but is in the graduate course; Washington feels that field work might be dispensed with, if necessary, in the undergraduate course; and Yale does not provide any field experience in its graduate course.† Courses elsewhere vary from three or four field trips per quarter or semester up to almost daily field work at several of the summer stations. The number of field trips per course most commonly lies between six and ten.

Field work can have either of two main objectives: It can serve to give the student *experience* in many of the field methods of limnology, or it can serve to *illustrate* some of the methods used in gathering the data on which the principles discussed in lecture have been based. The former objective is that of the school offering training in fish management and perhaps also of the school with an extensive graduate program in limnology. It is necessarily limited to small classes for reasons of logistics and mechanics. Where a class is large or less selected the second objective is much more appropriate.

The initial cost, storage, and maintenance of equipment can be a considerable problem, particularly at the smaller school, and, as might be expected, the variety of limnological equipment available varies tremendously from school to school. Cost of equipment is such that most institutions must acquire the desired items over a number of years.

Although limnology is quite widely taught today, particularly in the large, state-supported schools, opportunities for graduate work in the field are more restricted, depending on the size of the school and the diversity of its faculty. Ten of the institutions listed in Table 1 do not offer any advanced training in limnology: 27 offer the master's degree in zoology, with limnology as a specialty; and 30 offer the Ph.D. on the basis of limnological problems. Not all in the last group are equally important in contributing to the field. Of the persons teaching limnology in the United States at present, half have had their training in one of five Midwestern states—Michigan, Illinois, Wisconsin, Minnesota, and Indiana, in that order. The only other concentration of background is the Cornell-Yale-Harvard region, accounting for approximately one fifth of the total.

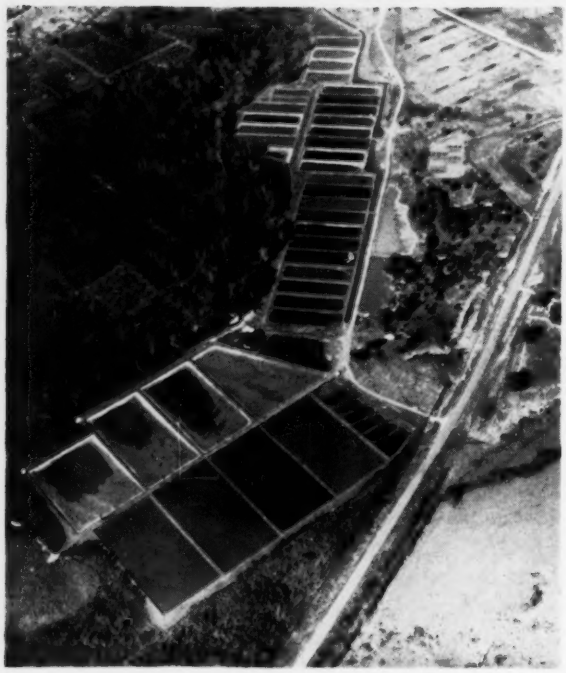
Recent studies (for example, Knapp and Goodrich, 1951) have pointed out the disproportionate

† If one recalls the fact that Hutchinson has trained such outstanding limnologists as Riley, Deevey, Brooks, and others, one doubts seriously that formal field training is a necessity.

Part of Jones Lake, North Carolina, showing the ancient cypresses characteristically draped with Spanish moss. The remarkable "bay" lakes in this region extend well back into Pleistocene time. (Photo by the author.)

importance of small liberal arts colleges in contributing to the ranks of qualified scientists in the United States, which raises the question of whether there is not some way the potential scientists at these institutions cannot at least be made aware of limnology and the opportunities it offers. Possibly a good means of accomplishing this to the benefit of ecology as a whole, and to the benefit of students through the broadening of their training, would be the setting up of balanced courses in general ecology in those schools where they are not already present. Out of 521 schools whose recent course catalogues were available at Indiana University, 45 per cent offer one or more courses in some phase of ecology. At some schools the courses are listed as field botany or field zoology, but it is clear from the accompanying descriptions that at least a modicum of ecology is given. Most courses are listed either as plant ecology or animal ecology, with the former predominating. Many schools with biology departments list the

Linsley Pond, Connecticut, a small natural lake which has contributed to fundamental advances in limnology out of all proportion to its size. (Photo furnished by G. E. Hutchinson, Yale University.)



One of the groups of experimental fish ponds at Alabama Polytechnic Institute used by H. S. Swingle and others in studying fertilization and fish populations. The largest ponds are 1 acre in area. (Photo furnished by J. S. Dendy, Alabama Polytechnic Institute.)

courses simply as ecology or general ecology, occasionally as bioecology, although undoubtedly these courses are often strongly slanted toward plants or animals, depending on the training of the teacher. There are also a considerable number of specialized courses such as range ecology, forest ecology, ecology of arable lands, ecology and control of weeds, insect ecology, trophic ecology, etc. In those schools where a student has the opportunity to take just one course in ecology, it is certainly desirable f him to be instructed in the over-all aspects of th subject rather than in some restricted man-mad compartment of the field.

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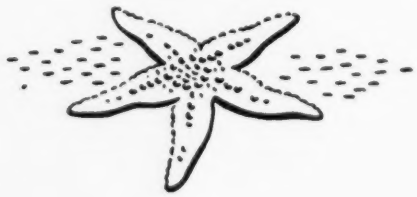

Teaching Ecology in Urban Areas with Emphasis on Insects

ORLANDO PARK

Dr. Park received a Ph.D. degree from Chicago in 1929 and is now professor of biology at Northwestern University. He is a noted ecologist with entomological leanings. He has two major research interests: the analysis of activity of animals and the study of beetles of the family Pselaphidae. *In 1943 he was President of the Ecological Society of America. He was one of the authors of* Principles of Animal Ecology *and is section editor of Animal Ecology in* Biological Abstracts.

AT PRESENT the entomologist can claim the greatest ignorance about the largest natural group of organisms. It is not feasible to discuss the teaching of ecology with the class Insecta suspended in a biological vacuum. Therefore, I shall discuss the teaching of ecology in urban areas and draw on insects for background material.

Teaching ecology in urban areas appears to me to contain no qualitative aspects that would differentiate it from teaching the same subject in rural areas. Being based in a large metropolitan center versus being based in a small rural center places emphasis on suitable means of transportation and amount of time available for actual field work. Given the same level of competence of instruction, amounts of field, laboratory, and library equipment, and the same quality of student material, an instructor offering a field course in an urban center has a longer journey to the place of study and consequently less field time in which to accomplish his objectives. Admittedly this is a great disadvantage but not an insuperable one. It may be likened to sucking water through a straw, instead of drinking from a cup—in the former case one has to work harder, and over a longer period of time to achieve the same result.

During the past thirty years several problems and increasingly acute trends have formed a complicated background for teaching field work in the Chicago area. These include the following: First, constantly expanding urbanization has often resulted in the destruction or impoverishment of formerly excellent study areas. This has meant the abandonment of the area, and the need to find other equivalent study areas or to change the type of field work. Second, constantly expanding urbanization has often required a more efficient method of transportation for class and equipment.

These two items, tied as they are to conservation of field resources, are no less acute now and probably will continue to increase in amount and kind. One example will suffice. In the early nineteen-twenties one could walk from Miller's (now part of Gary), Lake County, Indiana, along the southern shore of Lake Michigan, through Porter County, and into Michigan City, LaPorte County, Indiana, and see only a few people and dwellings. This was an almost unbroken stretch of the famous Indiana Dunes. Here H. C. Cowles studied the dune complex with relation to vegetation, and these experiences assisted in formulating his concept of physiographic succession.[1] This dunes region became one of the better investigated field areas of the world. An incomplete list of contributions would serve to document the thesis that when a brilliant mind formulates an important concept, the resulting contributions in field and laboratory bring substantial enrichment to that science in many ways, some apparently quite unrelated to the initial stimulus.

The Indiana Dunes, as I knew them between 1922 and 1925, are gone. Large sections should have been preserved as an inland biological station offering terrestrial and limnological research facilities. Indiana Dunes State Park was established in the eastern part of this region, but it was established too late and covered too small an area. This Park will serve to conserve certain habitat types, but the strips of raw dune complex from several miles inland to the Lake Michigan strand—the several forest types, fore-dunes, beach drift, open sand, *pannes*, blow-outs, streams, and the excellent series of ponds used by V. E. Shelford in his work on pond

succession—these communities with their diversified biotas have largely disappeared. Marshes have been drained, low areas filled in, and high areas cut down; villages have grown, mansions have been built on sod-stabilized sand, and bathing and recreational facilities have been provided; modern roads now traverse the region, and everywhere are the stigmata of urbanization.

Space has been devoted to the Indiana Dunes for a definite reason. In a discussion of the teaching of field work, direct or indirect ways in which future problems can be attacked or solved should be covered. If field work is to be taught there must be people trained to teach it and localities in which it can be taught. The fate of the Indiana Dunes is an example. In the Chicago area there is also the pollution of such streams as the Des Plaines River, drainage of marshes and of tamarack bogs, and the destruction of remnants of the Prairie Peninsula. The fate of the Indiana Dunes suggests that biologists should impress administrative circles of institutions of learning with the importance of conserving areas for future study. It is not true that teachers in rural places can have access to such areas whereas teachers in urban areas cannot. The former can reach the places more quickly or more conveniently, or they may spend more time there, but if the areas are impoverished, the advantages of the rural teacher disappear.

I should like to discuss the difficulties of teaching ecology in any area, with any group of organisms from algae to Virginia deer. We are all laboring under qualitatively similar disadvantages, which will increase. There was a time when we walked into the field or went by street car to the end of the line and then walked; or by local train and then walked, or by private automobile. Later, groups of private automobiles were used. About the same time the bus, either institution-owned or chartered, came into use. This had the advantage of getting the class and increasing amounts of impedimenta in one private vehicle. This is much the present status of field class transportation. Administrators of higher education have not been won over to the advantages of transporting field classes by airplane, with the institution paying most of the transportation cost.

A third difficulty is the practical restriction of most field work to Saturday or, at most, to over the weekend. Since a student's time is occupied with additional courses during the week, Saturday, with its competing attractions and crowded highways is left. Good field weather may fall on any day of the week, but the field class must take Saturday weather.

Fourth, at times there is what appears to be an administrative handicap on field work. I refer to the matter of credit hours. In some institutions a one-hour lecture is the basis of evaluation, and two hours of laboratory work is the equivalent of a one-hour lecture. Field work may not even be evaluated. On a quarter basis, a course in field biology may be evaluated at four credit hours. Such a course may have two hour lectures a week and laboratory work on collected materials from four to six hours a week. The course also uses from six to eight Saturday hours for from four to seven weeks. Some adjustment of credit hours, or their abandonment, might serve to increase student participation.

Fifth, regional location of the institution offering local field work is a factor that needs only brief mention. In the north, severe winters and late springs restrict most class field work correspondingly. Some regions can offer field work the year around. Institutions located in such areas can give field courses the year around and should do so.

Sixth, there is also the impact of theory and methods on field work. This important aspect deserves our attention. In any good field course the lectures of necessity are in a state of flux from year to year. New ideas require discussion. In a limited series of lecture hours this means an inevitable condensation or excision of other lecture materials.

Similarly, as new ideas are incorporated in field work there is an inevitable condensation or abandonment of other field work, or the expansion of the course into two courses given in different semesters or quarters, or even offered by different instructors. With such changes reorganization of the Saturday schedule is necessary; additional equipment is usually needed; and often new laboratory work is developed as a consequence.

Occasionally some new concept requires a completely new type of field organization; for example, the study by a field class of periodicity of activity. This requires a continuous observation and collecting period of at least twenty-four hours. This extended period of class participation requires camping-out, involving food and clothing, but an all-night-all-day trip is productive, even under poor weather conditions, and students seldom forget the impact of such an adventure. A nocturnal-diurnal analysis of the community, both physical and biotic, can range from simple to complex. It may employ full equipment for quantitative analyses, and in addition, sugaring certain trail stations, tape recorders with parabolic reflectors for picking up bird, amphibian, and insect sonification, and field telephones for interstation communication. On the

ther hand, a trip may employ no more than simple observation, with the class following the informed instructor from place to place. Under certain conditions there can be too much organization. We should beware "dry rot" here as in biology in general.[3] We should not neglect natural history.[4]

Finally, there is the matter of identifications. Poor taxonomy may lead to misinterpretation and ridicule. Good field work and good experimental work may be rendered worthless by misidentification. Students should receive expert assistance. Even after a quarter's work students seldom can be trusted to key out miscellaneous arthropods below suborder except in special cases. The instructor should be able to intervene to give the class data reliability. His own background determines the differential reliability.

Students should be encouraged (*a*) to appreciate the difficulty of the taxonomic method, (*b*) to discriminate characters and learn to compose a simple taxonomic key; (*c*) to study the principle of natural variation in a population; (*d*) to study the relation of the ecological factor of selection to the genetic factor of inheritance, and (*e*) to study such infraspecies categories as varieties and subspecies. The library and museum are usually valuable allies.[5]

We have discussed several difficulties that beset the teaching of a field course. The first two are sociological and tend to increase the handicap of teaching in urbanized areas. The third and fourth are largely administrative. The fifth is geographic. The sixth is a natural concomitant of research. The last deals with difficulties imposed by an exacting taxonomic viewpoint. This is not a complete listing; other difficulties will present themselves. Good field work is difficult; it is also important, if proper attitudes toward the scientific method and the conservation of natural resources are to be inculcated.

An appraisal of teaching objectives in field courses covers first the elementary course in field biology and then the advanced course in ecology.

The elementary course in field biology (field botany or zoology) includes:

1. *Principle of variation.* All natural populations vary. This variability in structure, function, heredity, and ecology bears importantly on the life of the individual, its community associates and the evolution of its kind.

2. *The taxonomic method.* After study of variation within a population, the student is more prepared to cope with differences as between allied species. This objective has been discussed previously.

3. *Subspeciation.* The general background should be covered in lectures. Students need an introduction to such things as selection, barriers, and dispersal paths, isolating mechanisms and other concepts since species populations are the building blocks of the community. These are deep and muddy waters even today.

4. *The scientific method.* From the standpoint of first things first, this is the essential item in the equipment of every biologist. Students should know how to set up a controlled experiment and be able to appreciate its philosophical value.

5. *Response to the environment.* (*a*) The varied and often delicate responses to *physical* factors allows an almost endless series of field and laboratory observations to be made. Numerous examples will occur to every one and need no amplification. This work is productive and stimulates student interest. (*b*) Students are less likely to think of responses to the *biotic* environment, although they are keenly aware of this aspect as it affects their own behavior. Feeding patterns and stomach analyses may be illuminating. Laboratory exercises are numerous and include response of leeches to blood-bearing hosts, of clam-mites to clam-gill extract,[6] of myrmecophiles to their hosts;[7] colonies of termites[8] and ants[9] also offer possibilities.

6. *Principle of succession.* This can be introduced at the elementary or the advanced level. The subject has been mentioned previously with respect to the Indiana Dunes and needs no amplification.

7. *Development of the microsere.* There is growing research emphasis on microhabitats and microclimates. In terrestrial microseres insects are important and easily studied. Microsere study can be made in the field and continued in the laboratory. Since most of these microseres eventually are incorporated in organic soil formation and, consequently, are without a climax stage, their study supplements community succession, prepares the student for the complexities of community metabolism, and should increase interest in soil conservation.

Such terrestrial microseres include those of carrion, dung,[10] fungus conk,[11] tree hole,[12] and the decaying log.[13, 14, 15]

The advanced course in ecology includes:[16]

1. *Principle of succession.* Noted previously.

2. *Principle of convergence of seres.* Convergence to a regional climax is an important concept but can best be handled by lectures and assigned reading, unless the institution involved is prepared to undertake much more than the usual responsibility for financing field trips.

3. *The population.* Growing emphasis on nat-

ural and experimental population ecology at the research level is a happy sign of progress. Until we know much more about populations it will be difficult to raise our sights to the community, where many interdependent populations are involved in survival.

4. *The community.* This is one of the most difficult subjects. It involves so many different kinds of things, operating differentially or jointly through time and space that the subject could occupy the full time of a course. Several aspects can be mentioned here, but the danger in this method is that the aspects may become identified as independent, with consequent loss of synthesis.

(*a*) *Mensuration of physical factors.* The daily march of the several operating factors should not be neglected in so far as they may interpret or augment current study, and if such data are accumulated for those parts of the community under investigation. Practical meteorology is not an ecological end, but should be correlated with ecological events in the lives of individuals, populations, or the whole community.

(*b*) *Community metabolism.* The student gains perspective in the realization that there is an ecologically similar web of feeding interrelations within any major community type the world over. Direct field observations often provide evidence of the behavior of herbivores, predators, and parasites. Stomach analyses augment field work; lectures and readings broaden the viewpoint.

It is at this last level that the student can be interested in trophic levels, pyramid of numbers, biomass, and productivity. It should serve also to integrate group appreciation of the group's own food web, the problems of conservation, and the dangers involved in unscientific efforts to control populations.[17]

(*c*) *Community structure.* The principle of stratification in the broadest sense usually can be demonstrated with success. Associated with this are important features of community life as the structural and behavioral adjustments of organisms to a given stratum, to habitat niches and their microclimates.

(*d*) *Community periodism.* This has been discussed previously.

(*e*) *The biome.* Distribution of biomes over the world, their climates, biotas, and adjustments is a stimulating subject but of such magnitude that it is usually developed in a separate course. From a field viewpoint it is seldom practicable to demonstrate several biomes within a few Saturdays of a quarter or semester. Until a class can be taken into the field for some extended period of time, or until cabin airplanes can be utilized, such concepts as the comparative study of biomes must be left to lectures and assigned readings.

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SCIENCE ON THE MARCH

RECENT PALEONTOLOGICAL DISCOVERIES FROM CUMBERLAND BONE CAVE

MANY European caves are noted for their rich supplies of fossils, but very few caves containing the remains of extinct animals are to be found in the United States. Except for deposits in Florida, however, our knowledge of Pleistocene remains of eastern North America is limited to caves. Perhaps the most outstanding source of our knowledge of Pleistocene fauna has been the Cumberland Bone Cave, in Maryland, yet today this cave is not well known at all. This is unfortunate, since not only do the remains found in the cave fill many gaps in the paleontological record of the eastern United States, but they also tell us much about the climate and topography of bygone ages. Even more information should now be forthcoming from this site since we have reopened a section hitherto considered inaccessible.

Before 1912, the entrance to the cave was apparently a sinkhole situated on a limestone ridge on the south side of Wills Creek Valley about three miles northwest of Cumberland, Maryland. The town of Corrigansville is now situated below this ridge. A vertical shaft led down to several small chambers and thence down to the main room of the cave, approximately 100 feet below the surface. It is easy to see how this shaft developed, since the strata of limestone are vertical, so that the lines of cleavage are in a nearly perpendicular position. This gave access to surface waters, which then caused the development of a typical fissure cave.

The cave must have been known to local residents before 1912; remains of old rifles were found in it and, according to one source, it was a hideout for early settlers during Indian raids. In 1912 the Western Maryland Railroad, in excavating for a cut while pushing their tracks through Cash Valley to Connellsville, exposed the cave. Unfortunately, dynamite was used to loosen the layers of rocks down to the level of the roadbed, which was at the same level as the main room of the cave. An alert amateur naturalist noticed the large quantities of bones being removed in the rubble and notified J. W. Gidley of the United States National Museum. All the bones exhumed before this time were lost except for a few skulls carried home by curious workmen. For the next four years Gidley accumulated from this cave one of the largest collections of mammalian fossils ever found in this section of the country. After Gidley's death in 1931, C. Lewis Gazin, curator of vertebrate paleontology at the museum, completed the classification of the remains and is at present assisting us in identifying the fossils discovered within the past two years.

As originally found, there were literally thousands of fragments of bones, intermingled with the dirt and breccia of the cave and in many cases cemented together so as to make identification difficult. Although broken up, the bones show no sign of being water-worn, and there is an absence of sand or gravel; the bones must have been intermixed as a result of carcasses being caught in crevices near the surface and gradually falling apart until the disjointed bones eventually worked their way down to the bottom of the cave. The remains range in size from bats to mastodons, and only the bats, of all the specimens described, could be called true cave animals.

The Cumberland Cave fauna exceeds that of other Pleistocene caves in the number of mammalian genera recorded, but it contains a slightly smaller number of species than found in the Port Kennedy deposit or the Conrad Fissure. Forty-five distinct species of mammals, in seven different orders, are represented in the remains, plus remains of a few reptiles, some snakes, and a lone alligator tooth. Of these species, twenty-eight are now extinct, and most of the others are not present-day natives of the region.

The accumulation of bones must have been gradual, although all the mammals are pre-Wisconsin in age. The diversity of type indicates that widely varying climate zones must have existed during the time of deposition. This has led to much speculation and has given evidence of more radical changes in environmental conditions than had been originally suspected. In this one cave have been found such types as the wolverine, grizzly bear, and Mustelidae, which are native to Arctic regions. Peccaries, the most numerous type represented, tapirs, and an antelope possibly related to the present-day eland are indigenous to tropical regions. Ground hogs, rabbits, coyotes, and hare remains are indicative of dry prairie, but on the other hand such water-loving animals as beaver and muskrat suggest a more humid condition.

Several explanations are possible for these puzzling differences of species. It may be that animals of species existing now differ in habits from ani-

mals of the same species existing then. This may seem improbable, but we have no proof that animals have maintained the same type of behavior and reactions through the years. Another argument advanced is that the temperature of the region when the bones were being deposited was warmer than now, except in the mountain ranges, which have since been worn down by erosion. This argument seems untenable, for, geologically speaking, the remains are recent and the mountains must have had the same general size range as those of today. Further, it is known that Wills Creek and the nearby Potomac River were higher than they are now, so that the entrance to the cave must have been almost level with the valley floor and there was much less relief than exists today. However, animals adapted to the cold could have penetrated the warmer valleys and lowlands during the winter.

The ice sheet might have been advancing so rapidly that species of different environments could exist contemporaneously in the same region. This condition could not have existed for long, however, and the tropical type would either have succumbed or fled south. Gidley regarded the African types as relics of a former Holarctic distribution.

The most logical explanation would seem to be that the remains accumulated over a sufficient period of time to allow for gradual change in climate from one extreme to the other. If a gradual time range of fifty thousand years is postulated for the length of time necessary to accomplish this, then the diversity of bones can easily be accounted for and still place the remains in the period usually assigned to them.

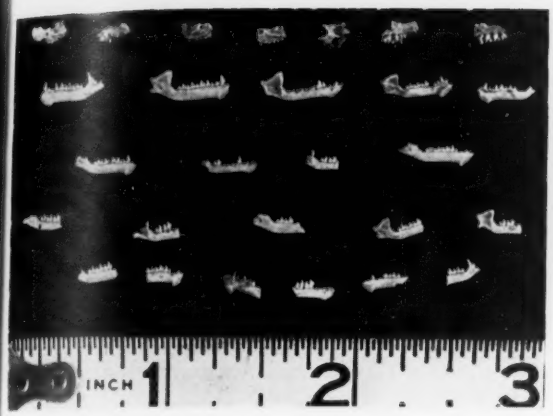
View of excavation overlooking original Bone Cave. Author standing on right.

As at present understood the cave remains represent the following vertebrates; the common name or name of an animal similar to that listed is given in parenthesis:

Loricata
  Crocodylid (crocodile)
Serpentes
  Ophidian remains (snake)
Galliformes
Tetraonidae
  Bonsa umbellus (linnaeus) (ruffed grouse)
Insectivora
Soricidae (Shrew)
  Sorex sp. (long-tailed shrew)
  Blarina brevicauda (Say) (short-tailed shrew)
Chiroptera
Vespertilionidae
  Eptesicus cf. grandis (Brown) (brown bat)
  Corynorhinus alleganiensis, n. sp. (big-eared bat)

View of trench being dug to cave.

Bone Cave open. Note stalactites on left.



Jaws of extinct bats range in size from ⅛ to ½ inch.

Carnivora
- Canidae
  - *Canis cr. priscolatrans* (Cope) (coyote)
  - *Canis armbrusteri* (Gidley) (coyote)
- Ursidae
  - *Euarctos vitabilis* (Gidley) (black bear)
  - *Arctodus haplodon* (Cope) (grizzly bear)
- Mustelidae
  - *Martes parapennanti,* n. sp. (marten)
  - *Mustela cf. vison* Schreber (mink)
  - *Gulo gidley* (Hall) (wolverine)
  - *Lutra parvicuspis,* n. sp. (otter)
  - *Brachyprotoma pristina* (Brown) (skunk)
  - *Spilogale marylandensis,* n. sp. (spotted skunk)
  - *Taxidea marylandica,* n. sp. (badger)
- Felidae
  - *Felis cf. inexpectata* (Cope) (puma)
  - *Felis near strox* Leidy (tiger)

Rodentia
- Sciuridae
  - *Marmota monax* (Linnaeus) (woodchuck)
  - *Citellus cf. tridecemlinaetus* (Mitchell) (ground squirrel)
  - *Tamias cf. striatus* (Linnaeus) (chipmunk)
  - *Sciurus tenuidens* (Hay) (red squirrel)
  - *Glaucomys* sp. (flying squirrel)
- Geomyidae
  - *Plesiothomomys potomacensis,* n. gen. and sp. (pocket gopher)
- Castoridae
  - *Castor canadensis* (Kuhl) (beaver)
- Cricetidae
  - *Peromyscus cf. leucopus* (Rafinesque) (deer mouse)
  - *Neotoma magister* (Baird) (wood rat)
  - *Parahodomys spelaeus,* n. gen. and sp. (wood rat (?))
  - *Synaptomys cf. cooperi* (Baird) (Lemming mouse)
  - *Synaptomys* (*Mictomys*) sp. (Lemming mouse)
  - *Microtus* (*or Pitymys*) (?) *cf. involutus* (Cope) (volve, field mouse)
  - *Ondatra cf. annectens* (Brown) (muskrat)
- Zapodidae
  - *Zapus* sp.
  - *Napaeozapus cf. insignis* (Miller) (jumping mouse)
- Erethizontidae
  - *Erethixon cf. dorastum* (Linnaeus) (porcupine)

Lagomorpha
- Ochotonidae
  - *Ochotona* sp. (pika)
- Leporidae
  - *Lepus cf. americanus* (Erxleben) (hare)

Froboscida
- Mostodontidae
  - *Mammut cf. Americanum* (Kerr) (mastodon)

Perissodactyla
- Equidae
  - *Equus sp.* (horse)
- Tapiridae
  - *Tapirus* sp. (tapir)

Artiodactyla
- Tayassuidae
  - *Platygonus cumberlandensis* (Gidley) (peccary)
  - *Platygonus vetus* (?) (Leidy) (peccary)
  - *Mylohyus exortivus* (Gidley) (peccary)
  - *Mylohyus cf. pennsylvanicus* (Leidy) (peccary)
- Cervidae
  - *Cervus* sp. (elk)
  - *Ococoileus cf. virginianus* (Boddaert) (white-tailed deer)
- Bovidae
  - *Euceratherium* (?) *americanum* (Gidley) (eland)

Fossilized remains of prehistoric elk.

Of the fossils found in the cave, seven are new species. One, a bat of the Vespertileonidae family, *Corynorhinus alleganiensis,* which resembles the big-eared bat, is the first record of this genus from the Pleistocene. Even living representatives of Corynorhinus have never been recorded in this region. Oddly enough, no trace has been found of *Myotis* in the Cumberland Bone Cave. *Myotis* was originally listed as having been found there because the dental formula of the lower jaw of Corynorhinus is the same as *Myotis.* A later study revealed, however, that the mandible found had a shorter premolar and longer molar teeth than *Myotis.*

Four of the new species are Mustelidae. The first, *Martes parapennati,* a marten, is similar to *Martes diluviana* from the Port Kennedy deposit. *Lutra parvicuspis,* the second of the species, resembles a type of otter found in Central and South America

today. It is smaller than the other found in the eastern United States, *Lutra canadensis*. Another member of this species has also been found in Port Kennedy.

A third mustelid, *Spilogale marylandensis,* or spotted skunk, is represented by three fragments of mandibles. The complete skull, lower jaw, eleven vertebrae, and a section of the right humerus of a badger, *Taxidea marylandica,* represent the last new species of this family. Since very few badgers are now seen east of the Mississippi, this is an interesting find. It is similar in size to *Meles meles,* but only fragments are known of two other species of Pleistocene Taxidea.

Two rodents, both representing new genera and species, have been identified. The first, *Pleisiothomomys potomacensis* is a member of the Geomyidae, or pocket gopher family. It differs, however, from two other genera of this family, *Thomomys* and *Geomys*. The other rodent, a wood rat, *Parahodomys spelaeus,* belongs to the Cricetidae.

Another outstanding group from the cave has been the remains of thirty or more peccaries, from which the complete skeleton of one individual has been reconstructed. Two genera, *Platygonus* and *Mylohyus,* have been encountered, with two species of each. The mastodon remains seem to be those of young individuals.

Undoubtedly many more bones were still embedded in the cave when loose rocks finally made any further investigation too precarious. The Western Maryland Railroad in 1915 blocked the entrance so successfully that all attempts to get into the remains of the cave were a failure. It should be noted here that the railroad did a wise thing in closing the cave, since it had become rather popular and there was the imminent danger of tourists being seriously hurt either by falling rocks or by passing trains. A group of us once spent two days working at the blocked entrance and were able to advance only ten feet. Further work on that section of the cave is now impossible. However, elderly local residents have stated that the cave extended underneath the hill for some distance. The whole area about the cavern was carefully traversed, but no evidence of other openings was found, with the exception of a large sinkhole one mile west of the former opening. The owner of the orchard on which the sink is located claims that water drains out of the bottom. This hole, extending down about twenty feet below the surface, was carefully investigated, but no traces of a passageway could be found. It does appear that the hole is gradually widening, and it may be that this is a "back door" to the cave.

Remains of peccary taken from Cumberland Bone Cave.

The only other clue to the fact that the cave underlies the hill was found in an abandoned quarry two miles south of the present entrance. Several small openings pierce the wall of the quarry and then connect inside to continue as a winding passage for forty feet. Broken rock and dirt prevent further progress, but the passage seems to have collapsed only recently, probably because of the blasting operations of the quarry. If the passage continued in the same direction, it would connect with the Cumberland Bone Cave, since it is situated in the same hill.

After several visits to the site in the autumn of

Left and right mandibles of extinct bear, *Euarctus vitabilis.*

1950, it was noted that numerous weathered stalactites, stalagmites, and flow stone could be discerned on the exposed sides of the cuts. This indicated the former location of the cave, and from this we were able to deduce the general pattern of the original cave. It seemed that at least one of the smaller chambers should still exist on the opposite wall. A small opening was made about thirty-five feet above the tracks. Then followed a memorable moment. The first member of the party had no sooner squeezed through the opening than he found a bone stuck in a crevice. Upon examination it was identified by Dr. Gazin as the complete mandible of *Euarctus vitabilis,* a large bear now extinct. This was a good indication that a portion of the original drop had been found.

Further exploration of this room revealed that it was about twenty feet deep, ten feet wide, and two feet high. Careful digging operations were started in the dirt floor, and other bones soon came to light. An immediate problem arose as to the disposal of the dirt. Conditions were crowded, and the narrow entrance made shoveling of dirt impossible.

A second opening was then dug, connecting to the remnants of the chimneylike formation. This afforded an entrance into the actual site of most of the findings. As a result of this, dirt and rocks were gradually shoved toward the front entrance while access was obtained through the top of the chamber. By 1951, parts of the room had been excavated to a depth of two feet; work progressed slowly since each shovelful of dirt had to be sifted. After getting below the first foot, bones turned up with an encouraging frequency. Some of these were obviously recent, but many were heavy with mineral impregnation.

In 1952 operations had to be halted as there was danger of undermining the whole cliff, since the cave was found to extend through to a quarry. In addition, ventilation was so poor that respirators had to be worn, and goggles were needed as a result of the dust raised. However, through the interest shown by George Howarth, vice president and general manager of the Western Maryland Railroad, an agreement was reached whereby the railroad promised to remove the upper strata of rock down to the cave level, thus removing the danger of collapse, also permitting the opening of the cave to light, and thus solving the ventilation problem.

In December 1952 work resumed with the removal of several hundred cubic yards of rock to reach the floor of the cave. Then the walls were carefully removed, the debris being constantly searched for bones. Because so many remains were found lodged in crevices, dynamite had to be used sparingly to preserve the fossils. This meant that more time was required to complete the job, but the Western Maryland has generously continued to support the expense of opening the cave until the job is completed. The excavated rock and dirt are removed by placing a work train in the cut below the cave and scooping up the material with a railroad crane.

Actually, there is slight resemblance to a cave now. Rather, there is a cut forty feet deep, twenty feet wide, and fifty feet long at the bottom of which lies the dirt yet to be investigated. It is hoped that a solid floor will eventually be found under the dirt. Here there are likely to be crevices and joints where large bones would be caught. Some bones may be encased in the rocks, as was the situation in the original bone cave.

In conjunction with work being done on this cave, other caverns in the region have been investigated by us. Since September 1950, twenty-three new caves have been found within three miles of Cumberland. These and known caves of the territory have not yet yielded any remains that have been definitely established as being fossils, although a fair number of extinct species have been found. The only fragment which may be considered of interest is the top half of a femur of some sort of bison. This was discovered several years ago by a group while searching an unreported cave near Harpers Ferry, West Virginia.

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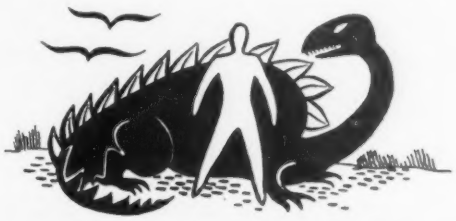

THE ONION SET INDUSTRY OF SOUTH HOLLAND, ILLINOIS*

SEED production is a highly specialized form of agriculture, requiring the use of special skills and environmental conditions. Unique industries have resulted from this fact, especially in the culture of bulbs used as seed. A well-known industry of this type is found in and around Holland, Michigan, the tulip center of the nation. Another bulb production center not so well known, but of national importance in horticultural circles, is located at South Holland, Illinois. Known locally as the South Holland area, this production center is noted for the growing of onion sets.

The South Holland area, less than 10,000 acres in size, produces more than half, and markets virtually all, the commercial onion set crop of the United States. The area is 20–30 miles directly south of Chicago, in Cook County, and is adjacent to the Illinois-Indiana state boundary (Fig. 1). Of the five hundred farm operators in Thornton and Bloom townships, in which the South Holland area is situated, more than 40 per cent raise onion sets and 94 per cent of the set growers are of Dutch origin. The concentrated production within fifteen square miles of between 500,000 and 1,000,000 bushels of onion sets yearly is an interesting example of agricultural specialization and concentration.

The Onion Set Industry of the United States

A general understanding of the nature and distribution of the industry within the United States is necessary to a consideration of the characteristics of the South Holland area.

Set growing is the second stage in a three-year cycle from seed to consumer. Seed is produced the first year from onion bulbs planted for that purpose, and a portion of the seed is then purchased by set growers in various parts of the country. The second year the seed intended for sets is planted thickly, about fifty pounds to an acre. This method stunts the growth of the plants and provides the grower with the small mature bulbs called onion sets. These are in turn planted the following year by home gardeners, truck farmers, and commercial onion growers.

Although a comparatively small industry, the commercial onion set industry grosses about one million dollars annually. Only 5 per cent of the total commercial onion crop in the United States are grown from sets. Approximately 3 per cent of these sets are grown by the onion producer for his own consumption, and so would not be classified as commercial sets. Almost all commercial onions are grown either from transplants or directly from seeds. The greatest buyer of commercial sets is the home gardener, who purchases them by the pound, quart, or bag, from seed, hardware, grocery, or drug stores.

Commercial onion sets are raised in only a few small areas of the United States: in the west, Greeley, Colorado, and Corvallis, Oregon, produce a small percentage. The Toledo, Ohio, and Louisville, Kentucky, areas, although significant producers in the past, are of little importance today. Minnesota has recently produced some sets, though its contribution has been extremely irregular. Racine and Kenosha counties, Wisconsin; Lake County, Indiana; and Cook County, Illinois, commonly referred to in the industry as the lower Lake Michigan region, produce more than 95 per cent of the total crop.

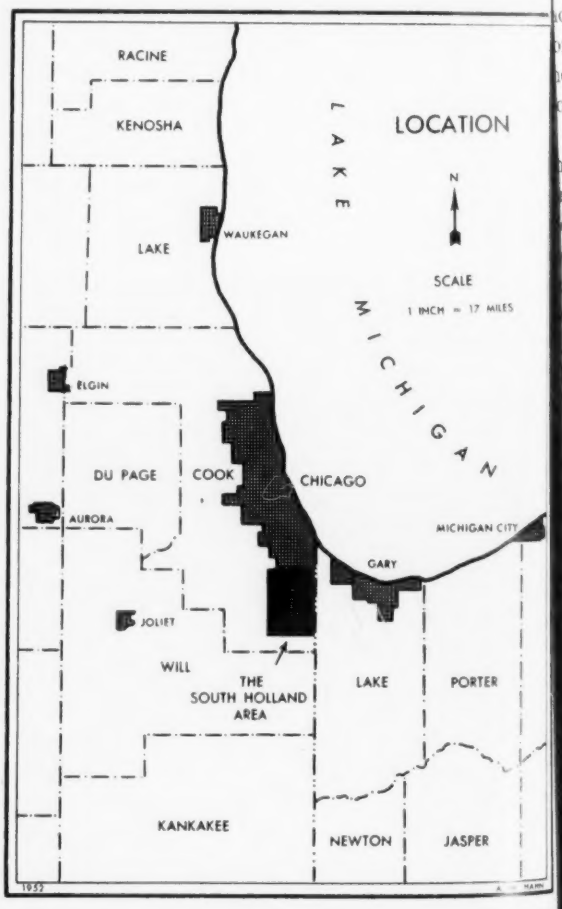

FIGURE 1.

* Data pertaining to this industry were obtained chiefly through personal interviews made within the area by the author during the summers of 1951 and 1952.

FIG. 2. Portion of the level lake plain near South Holland, Illinois. Note stacks of onion set crates.

South Holland is primarily an area of Dutch ttlement and Dutch-dominated agriculture and dustry. Outside of the Dutch the population is mposed mainly of people of German descent. Of e eight shipping agencies in the area only one is t directed by Hollanders.

Onion sets are the largest individual crop in e area, but other crops are important from both economic and an acreage standpoint. The uth Holland area embraces approximately 7800 res of agricultural land within two townships, d 30 per cent, or 2408 acres, is planted in onion ts. The remaining twenty-two townships of Cook ounty produce a combined total of less than 00 acres. About 65 per cent of the agricultural nd within the area is devoted to crops other than nion sets, although no single crop occupies more han half as much land as that occupied by sets. omatoes and sugar beets utilize 15 per cent and 1 per cent of the area, respectively, and are the wo most important vegetable crops. Dry onions nd asparagus are also notable from an acreage tandpoint; the remaining vegetable crops are of inor importance. Among the general farm crops, creage in corn is as important as oats, soybeans, lfalfa, and wheat combined. Agricultural land ot used as cropland may be classified under two ategories—wasteland and woodlot. These land-se types occupy about 5 per cent of the total.

The physical environment is generally well suited for the growth of high-quality onion sets. The moderating influence of cool winds off Lake Michigan, especially in late spring and early summer, helps to make temperature conditions almost ideal. Precipitation is adequate, although convectional storms, especially in the middle and late summer frequently create drainage problems already made difficult by the low flat surface of the lake plain occupied by most growers (Fig. 2).

The silty clay loam and silt loam soils, 12–18 inches thick, which cover most of the land used for set raising, are unusually fertile and generally well suited for sets. The Dutch farmer, however, through his tenacious efforts in draining these soils must receive primary credit for their present suitability.

The onion set industry entails a year-round operation, in which mechanization now plays an increasingly important part. Locally constructed seeders, cultivators, harvesters, and processing equipment have greatly increased efficiency in production and considerably lessened dependence upon manual labor, although it is still an important factor in most operations (Fig. 3).

There is evidence of a varying intensity of labor utilized on farms of different sizes. On farms of less than ten acres, there is one laborer for every two or three acres of cropland. On farms larger than one hundred acres, there is one laborer for every nine or ten acres of land. On the average, the ratio is approximately one laborer to every seven or eight acres of land. With the increase in size of farms, therefore, the amount of land tended by one laborer increases, or the number of laborers per given amount of acreage decreases. Doubtless the more intensive farming on the smaller farms on the

one hand, and the greater utilization of mechanized equipment by the larger operators on the other, explain this condition, at least in part.

Both yields and prices of onion sets have been unstable throughout the history of set growing in South Holland. The profits of high yields are usually offset by corresponding lower prices of sets, and in years when per acre production is low prices may be contrastingly high. However, when comparing average yields and average prices of the past decade with the two decades prior to 1940, two significant facts may be noted: (1) Average yields of the past ten years have increased by 18 per cent over the 1921–30 period and by 29 per cent over the years 1931–40. (2) Average prices of the past ten years, excluding World War II, have decreased by 4 per cent over the 1921–30 period and 11 per cent over the years 1931–40. Thus it is noted that the increase in yield of the past decade was from two to three times as great as the decrease in prices. Acreage has remained constant except for the World War II period.

The average annual gross income to growers in the South Holland area during the past thirty years has been approximately $750,000. During the past decade, excluding World War II, about $854,000 was received annually, and in the periods 1921–30 and 1931–40 approximately $720,000 and $666,000 were derived, respectively. Thus, despite declining prices, increases in yield have produced a total income during the past decade which is substantially higher than either of the other two ten-year periods.

Total capital investment in the South Holland onion set industry is estimated to be approximately $2,500,000, about one half of which is in mechanized equipment. More than $350,000 is spent on set harvesters alone. The remaining portion of capital expenditures is used for such things as warehouses and onion set crates.

About two thirds, or approximately 750,000–1,000,000 bushels of the sets marketed annually by the local agencies are grown in the South Holland area, and the remaining one third is grown in other portions of northern Illinois and southern Wisconsin. About 60 per cent of the sets sent from South Holland are shipped by rail, although truck transportation is gaining in importance here as elsewhere.

FIG. 3. Hollanders using onion set grading equipment.

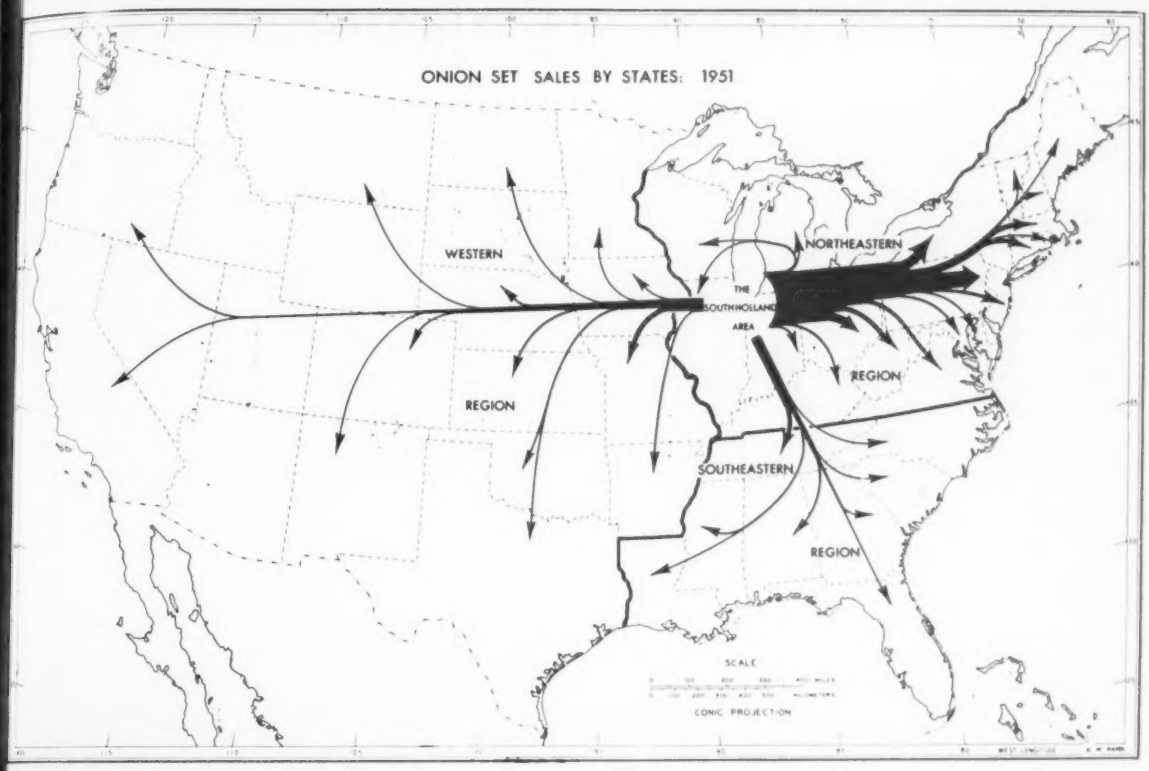

FIGURE 4.

Onion sets are distributed by South Holland shippers to at least forty-one states, which may be divided into three regions, commonly used by South Holland dealers in referring to the distribution of their product (Fig. 4).

As might be anticipated, the northeastern region serves as the purchaser of most of the sets marketed from South Holland. This region contains approximately 53 per cent of the total population of the United States, but it serves as a consumer for about 71 per cent of the total South Holland shipments made by rail. The southeastern region shows the second most important consumer concentration. Here 15 per cent of the total United States population purchases about 12 per cent of the sets marketed from South Holland by railroad. In this region the percentage of sets sold might be somewhat higher if the destinations of shipments by truck were known. South Holland set consumption, when compared with population concentration, is of least significance in the western region. Here 32 per cent of the total population of the country purchases only 17 per cent of South Holland sets.

The outlook for the onion set industry of the South Holland area is good, although it warrants constant observation. The national reputation of South Holland for high-quality sets should continue to grow as prospective increases in demand are met with continued high-quality produce. Despite lower prices, it is assumed that continued research and accumulated capital investments, especially in equipment, should further develop efficiency in operations so that continued satisfactory profits may be obtained. Slight shifts in distribution of consuming areas should in no way affect the currently favorable position held by the South Holland area compared with that of other producing areas, but might serve to encourage even greater production stability within the local area than heretofore. The physical environment is almost ideal at present, and its utility may improve as new and better methods of fertilization are more universally accepted and applied. Skills, techniques, interest, and devotion related to this type of agriculture, either transmitted or developed by the present-day Dutch farmer, have contributed significantly to the success of the industry up to this time. They may be expected to be passed on to the next generation, the Dutch farmer of tomorrow. These qualities will add to the prospects for a good and stable future within the South Holland onion set industry.

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BOOK REVIEWS

THE ANTENNA PROBLEM

Antennas: Theory and Practice. Sergei A. Schelkunoff and Harald T. Friis. New York: Wiley, 1952. xxii + 639 pp. Illus. $10.00.

Advanced Antenna Theory. Sergei A. Schelkunoff. New York: Wiley, 1952. xii + 216 pp. Illus. $6.50.

Radio Antenna Engineering. Edmund A. LaPort. New York: McGraw-Hill, 1952. xii + 563 pp. Illus. $9.00.

RADIO antennas have been part of our technical art since the time of Hertz' dipole oscillator and corner-reflector receiver of some eighty-five years ago. Theoretical problems associated with antennas have occupied the attention of some of the best applied mathematicians and physicists from that time until the present. The past decade, however, has witnessed rapid developments in the art and a large increase in the number of physicists and engineers who are concerned with radio antenna problems. Nearly all engineering colleges now offer courses in electromagnetic radiation, and the rapid expansion of this field is evidenced by the large number of antenna books that have recently appeared. Three of these books are reviewed here.

The theory and practice of antennas are covered by two well-known members of the Bell Telephone Laboratories, at a level suitable for advanced undergraduates and beginning graduate students. Following an introductory chapter which surveys the material to be discussed, Maxwell's equations are introduced (without use of vector analysis) and applied to plane wave propagation. A chapter on spherical waves, both in free space and on diverging wires, provides a lucid introduction to radiation phenomena. Three chapters on the directional properties of antennas and arrays include methods of antenna synthesis and a discussion of superdirective arrays.

A chapter on antenna current gives a thorough and understandable analysis of the factors that affect antenna current distribution. The clarity of the treatment here, as throughout the book, reflects the authors' long experience and their deep understanding of the subject. Impedance as a function of a complex variable is treated, and then the impedance characteristics of antennas are covered. The last six chapters dealing with antenna practice give an excellent and authoritative summary of the present state of the art.

The engineer, the teacher, and the student will all find this book a delight to read. For here the complicated phenomena of electromagnetic radiation are presented with rare simplicity. The book is comprehensive and thorough and contains a large amount of new and original material. It is unusual also to find so much high-level quantitative discussion presented without the use of mathematics beyond what is normally acquired by the undergraduate. It is doubtful whether any single author could have achieved such a happy combination of theory and practice.

Advanced Antenna Theory is for antenna specialists, advanced graduate students, and workers in the antenna field. It presents a unified account of recent developments in fundamental antenna theory. The author classifies antenna theories into two types—namely, circuit theories, in which the emphasis is on the current and charge in the conductors; and field theories, in which the emphasis is on the fields, the conductors appearing only as the boundaries. Hallen's theory of cylindrical antennas belongs in the first classification, whereas Stratton and Chu's solution for spheroidal antennas and Schelkunoff's theory of conical antennas and thin antennas of arbitrary shape come under the second classification.

An introductory chapter on Spherical Waves summarizes background material required for later chapters. A long second chapter on Mode Theory of Antennas presents a systematized treatment of the author's own antenna theory. Mode, or wave-guide, theory of antennas treats the antenna as an opened-out waveguide capable of supporting many modes, each of which may be described by a conventional transmission line diagram. In contrast to mode theory, the resonator theory of antennas is developed in Chapter 3 in connection with the solution for spheroidal antennas. A chapter on integral equations prepares the way for a comprehensive treatment of Hallen's method of solution for cylindrical antennas. A final chapter on natural oscillations, and several appended tables containing information of value for solving numerical problems, conclude the book.

Most of the material presented is new. In the words of the author, "to obtain the most general solution of Maxwell's equations is easy; to find that particular solution which satisfies the various supplementary conditions is far more difficult." One of the unusual features of this advanced text is the number of examples of particular antenna configurations that are set up for solution, mostly by the method of spherical mode analysis. Schelkunoff does more than set forth antenna theory. He stresses the physical interpretation of the mathematical methods employed. This approach is one that the engineer and physicist find most satisfying because the insight so gained assists them in their job, which is "the mathematical formulation of physical problems in a manner that will lead to correct results." Without doubt this book will become a classic in the field of electromagnetic engineering.

LaPort, chief engineer of the RCA International Division, has written an antenna design book, based upon the knowledge and experience gained from thirty

years of engineering on low-, medium-, and high-frequency antenna systems. In addition to a long chapter on each of these three subjects, it covers radiofrequency transmission lines, graphical synthesis of impedance matching networks, and logarithmic potential theory. Several appendices give useful information on penetration depth of earth current, mutual impedance, radiation patterns, and world noise zones, as well as a very extensive bibliography. The book is different in the respect that besides the radiation properties of antennas it considers the matching networks and mechanical engineering for each type. Although it is true that antenna theory is the same for all frequency ranges (although the permissible approximations may be different), the mechanical design is very much dependent on frequency. Besides several hundred line drawings, the book has about 55 pages of photographs showing installations and structural details of actual systems. The treatment of transmission lines as antenna feeding and matching networks at high frequency is quite thorough. Material on such important practical topics as factors involved in the choice of antenna sites is not likely to be found elsewhere in published form.

This is a practical "recipe" book giving detailed design and construction information on antennas made of wires, and masts and towers. It is intended particularly for field and operating engineers who may be called upon to select and construct antenna systems for use at frequencies below 30 mc.

It would be expected that there might be considerable overlap of subject material among three books dealing with antennas. Such is not the case, however, and each of these books deserves its own place on the bookshelf of the engineer or physicist who is concerned with antennas. In addition, Schelkunoff's advanced text is to be highly recommended to the applied mathematician who is seeking problems to test his ingenuity and skill.

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BRYOZOA

The Tertiary Cheilostomatous Polyzoa of New Zealand. David Alexander Brown. London: British Museum (Natural History), 1952. xii + 405 pp. Illus. £4 10*s*.

Dr. Brown's study was published as a monograph, independent of the preceding five volumes grouped under the title of *Catalogue of the Fossil Bryozoa*, issued from the Geological Department of the British Museum (Natural History). He elected to use Thompson's word "Polyzoa" in preference to Ehrenberg's "Bryozoa." The holotypes, some paratypes, and other specimens figured by Dr. Brown are deposited in the museum.

In discussing the previously published papers that included Tertiary Bryozoa from New Zealand, Brown calls attention to the inadequacy of the descriptions, and especially of the illustrations. His monograph includes a restudy of the collections of T. Hincks, G. R. Vine, A. W. Waters, E. C. Jelly, J. W. Gregory, J. E. Tenison-Woods, Bracebridge Wilson, F. Canu and R. S. Bassler, G. Busk, P. H. MacGillivray, W. H. Cawne Warren, and F. W. Hutton, to the extent of their availability. He also studied collections from (1) Waipipi, (2) Wanganui, (3) Hawkes Bay, (4) Mangamak Horizon, Hunterville, (5) North Canterbury, Weka Pass, Dovedale Stream, Waipara River Crossing, (6) North-West Nelson, (7) North Otaga, MacDonalds Quarry, Oamaru, Campbells Beach, All Day Bay, Otepopo, S. D., and (8) Southland.

Some of the collections were not localized in detail; hence their full stratigraphic values were lost. Other faunules were incompletely sampled, but those that were excellently secured serve as dependable guides to the ecology and stratigraphy of the formations from which they were taken. Dr. Brown's work illustrates how Bryozoa can be used in making correlations and ecological interpretations as dependable and accurate as those based upon any other group of organisms. The accuracy of the results depends upon the thoroughness in the study of the microdetails, as well as proper interpretation. Some of the results are illustrated in the distribution table, which shows the range and stratigraphic correlation of the 147 species and 15 varieties identified from New Zealand, with those known to occur in Australia. His comparisons with other localities are very general.

Brown bases his classification upon the work of Canu and Bassler (1917–35), Hincks (1880), Busk (1852–84), Levinsen (1909), Harmer (1902–34), Hastings (1930–49), Marcus (1921–42), and Silén (1938–44). He finds that there are many points on which it is impossible to accept the views of Canu and Bassler, whom he follows with respect to the units above the genera, but with whom he differs in the definitions of certain genera.

The classification of the Ascophora by Silén is "based chiefly on the hypothesis that the Cheilostomata and the Ctenostomata are closely related and sprung from common ancestors in the not far distant past." This view is not adopted by Dr. Brown, yet Silén's discussions influenced him to devaluate the importance of the ovicells in classification to a much greater extent than Canu and Bassler. Brown agrees in part with the Jullien and Calvert classification by considering the frontal wall of the orifice an important feature. Whenever the structural data alone are used, his classification is more closely allied with the work of Canu and Bassler than with that of other specialists in this field.

The body of the monograph, from page 42 to page 378, consists of the descriptions of species and genera, with text figures and diagnostic discussions of a few of the families and higher units of his classification.

It is necessary that a student of Bryozoa should have access to Dr. Brown's monograph, whether he is following the biological trend of bryozoan development during the Tertiary, or dealing with problems of ecology and disposition of the Cheilostomatous population in Tertiary seas.

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BUILDING CURRICULA

Improving Undergraduate Instruction in Psychology. Report of a study group supported by the Carnegie Corporation of New York and the Grant Foundation which met at Cornell University, June 27–August 16, 1951. Dael Wolfle, Chairman. New York: Macmillan, 1952. vii + 60 pp. $1.25.

FROM the psychologist's standpoint, the recommendations of this study group are grounded in the scientific point of view. From the educator's standpoint, they are traditional rather than functional—assuming such clear-cut dichotomies possible.

First, the authors propose objectives of undergraduate instruction in psychology. Of the three legitimate objectives discerned (knowledge, habits of thought, and attitudes and values), the first is to be stressed. The recommended curriculum consists of introductory courses (most important), elementary special-interest courses, core courses, advanced courses, and integrating courses. Although intended primarily for the liberal arts student, they also consider this array the best kind of training for prospective psychologists.

The course outlines are valuable, showing differences in the developmental and the cross-sectional approaches to introductory courses. The use of one type of approach, in the opinion of the study group, should preclude the use of any part of the other by a given author of a textbook. Other course outlines presented are for perception, motivation, thinking and language ability, and statistical reasoning.

That the authors do not set themselves up as a group intending to dictate the psychology curriculum in every situation is borne out in a number of places. They imply, for example, that alternates to the proposed curriculum are entirely possible in given situations. And, in the last chapter, they suggest research problems intended to help in the resolution of certain questions which, in the study group, were solved by general agreement.

The authors hold little hope for fulfilling the personal adjustment and growth (mental hygiene) objective for courses in psychology, suggesting that most psychologists should not assume the role of therapists, this function belonging to other institutional personnel. Hence, there would be no "psychology of adjustment," for example. But, if one of the objects of education is to form, the psychology of adjustment could well contribute by pointing up the various facets of adjustment and the means for attaining them, as well as to propose a unifying principle which serves an integrating purpose. It is not clear that subsidiary aims, such as the promotion of adjustment, in addition to major emphasis on psychology as a liberal arts discipline, detract from the value of the courses for certain students. The movement to widen the horizons of higher education unquestionably will bring students to many college campuses who need adjustment in addition to training. Why should not the psychology teacher aid student personnel officers by being, at least in part, concerned with the student's personal and social growth? The answer to this question will vary from one institution to another and even from class to class because the complexion of study groups, in terms of mentalities, behavioral characteristics, experiences, and needs, varies widely. Are we building psychology curricula for psychologists or for students? The question is pertinent in any institutional setting.

Instructors in psychology should welcome this little book, compressed in size but meaty in content. It would be expecting too much that all readers will agree with all the recommendations made, but there will be few indeed who, in their day-to-day association with their classes, have not come in contact with most of the problems presented. The book is worthy of wide circulation and thorough reading. This reviewer feels that the authors have made a significant contribution to better instruction in psychology.

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BRIEFLY REVIEWED

From Lodestone to Gyro-Compass. H. L. Hitchins and W. E. May. New York: Philosophical Library, 1953. 220 pp. Illus. $4.75.

THE history of instruments is not only a fascinating subject but also a most useful one, for it provides us with the means to judge ancient science objectively. The achievements of the ancient author or scientist depended very much on the precision and range of his tools. Hence, a story of the compass written by two British naval officers well acquainted with modern navigation instruments and familiar with their use from practical experience should be welcomed.

The earlier chapters on the compass in legend and history, on magnetic charts, and on errors of the magnetic compass in a ship and their discovery in the course of time make pleasant reading, although they have suffered from lack of acquaintance with foreign literature, as is also proved by the short bibliographies accompanying each chapter. We miss several important books, such as A. Ritter von Urbanitzky's *Magnetismus im Altertum* (Vienna, 1887), E. O. von Lippmann's *Geschichte der Magnetnadel* (Berlin, 1932), and Winter's essay in *Forschungen und Fortschritte* (Vol. XV, 1939).

The last 150 pages deal with the nineteenth- and twentieth-century developments of the magnetic compass, their transmission, the gyrocompass, compasses for aircraft, inductor compasses, and sun compasses. These chapters, well written and illustrated with well-drawn figures, will suit the general reader admirably. This book is a good example of first-class popular science in the best sense of the word—explaining in simple terms but at the same time conveying real information.

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I Drank the Zambezi. Arthur Loveridge. New York: Harper, 1953. xiv + 298 pp. Illus. $4.00.

ARTHUR LOVERIDGE, of the Museum of Comparative Zoology at Harvard University, knows and loves his Africa and its natural history. His latest trip was made in 1948, to Nyasaland, a province new to him. He was accompanied by his wife and her sister; the latter acted as chauffeur as well as ardent collector of small creatures.

Conditions in Africa had changed a great deal since his previous journeys there, and much destruction had taken place in the forests. Imagine having to buy wood for your campfire from the government when you are camping on the edge of a forest in Equatorial Africa! Even the price of dead monkeys had doubled. The animals were brought in and the collector kept the skull and skin for the museum, but turned the meat back to the hunter to be eaten.

This region was studied a century ago, but numbers of the species then described had not been taken since, and one object of the trip was to collect topotypes of of these little-known species.

Camps were made in the lowlands along streams and on the high Nyika Plateau at an altitude of 7500 feet, and specimens were caught in every camp—some long-lost species, and others new to science. "Snakes were present at Mtimbuki in pleasing variety," and all members of the party, assisted by natives, brought in daily what they had found. Often the porters were women, and out of forty of these, fourteen carried babies on their backs, as well as loads on their heads.

Although the expedition wanted some of the larger animals, most attention was paid to the smaller ones, such as the elephant shrew, the blesmol, and squirrels; land shells were found by the hundreds, and lizards, snakes, and frogs. After all, Loveridge is primarily a herpetologist, and there is as much thrill in capturing a long-lost lizard or a new species of snake as in obtaining a species of zebra in order to decide the question of whether it was really different from others, as had been stated years before.

One of the things that Loveridge wanted was Müller's clawed-frog, but he was unable to get into the exact locality where it occurs. The storks could, however, and the collector ingeniously shot one that carried half a dozen of these desiderata in its gullet.

It is a splendid narrative of an interesting and sometimes thrilling collecting trip, with observations not only on the animals but on native habits, told with appreciation and a sense of humor. There were exciting times, but Loveridge did not get excited. There were hardships, such as going through an unusually arid season and then an unusually wet one. With chigoes in his toes, bot-fly larvae in his leg, and stinging ants everywhere else, he still enjoyed it. So will the reader.

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Eiweiss. Heinrich Hellman. Stuttgart: Schwab, 1952. 163 pp. DM 5.80.

WITHOUT protein, life is unknown. With this thought Professor Butenandt, Nobel laureate, begins the foreword he has written to this little volume by his associate of many years in the Institute for Biochemistry at Tübingen. Dr. Hellman has undertaken to present in a concise but quite extensive fashion the present knowledge of the chemistry of the proteins as a class and of certain ones having special biochemical significance. In accord with the plan and the restrictions of space, the exposition is essentially categorical but is evidently drawn from a great fund of knowledge that has been carefully weighed and assayed. Numerous investigators are named but without references to their publications. The bibliography, a brief listing of monographs, does not include the recent (1950) comprehensive book of F. Haurowitz.

After brief discussion of the constituent amino acids, of their properties and form (designated in lower case), and of the peptide linkage and the dimensions in the peptide chain, of the influence of hydrogen bonds, the disulfide linkage and salt bridges on the organization (folding) of the proteins, the fibrous proteins and their α and β forms and the globular proteins in native and denatured forms are considered. Methods are described for the isolation and purification of proteins from natural sources, with especial attention to procedures based on solubility properties, and on the use of ultracentrifugation and electrophoresis; for the determination of molecular weights, and of the shape of protein molecules, as by birefringence of flow and with the electron microscope. Studies on the hydrolysis of proteins by acids, alkalies, and specific enzymes, and of the separation, identification, or the determination of the resulting amino acids by ionophoresis, selective adsorption (chromatography) on columns or paper, partition separation, as by the Craig countercurrent technique, by isotope dilution, and microbiological assay, have been outlined. Studies on the arrangement of the individual amino acids in the protein molecule, culminating in the work of Sanger on insulin, are described.

The concluding third of the book presents brief, rather cursory surveys of enzymes, including the better-known coenzymes, the hormones of protein nature, protein toxins, viruses, hemoglobin and other blood proteins, including the immunoglobulins, and, finally, of the metabolism of the proteins and amino acids.

This little book may be recommended to those who desire a brief authoritative survey of proteins at about the level of a good course in introductory biochemistry. It may be pointed out that the practical absence of the more intricate sentence patterns makes for easy reading of the German text.

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Tornadoes of the United States. Snowden D. Flora. Norman: University of Oklahoma Press, 1953. xiv + 194 pp. Illus. $3.50.

THE author of this, the first volume concerning tornadoes, has studied these fascinating storms (often wrongly called cyclones) with exceptional care for many years. For thirty-two years he was the section director for Kansas of the U. S. Weather Bureau. He has written many scholarly articles on individual storms, but this book can be read with enjoyment by almost anyone. It discusses all the chief aspects of these storms and their occurrence, and includes many suggestions for mitigating their damage. Tables and maps of frequency as to area, month, and hour of the day supplement brief descriptions of especially disastrous storms, arranged by cities, states, and years. There are numerous illuminating photographs.

Tornadoes have occurred in every one of the American states, and in each of the months. Although they are most frequent in the Midwest, hundreds have occurred recently in the South and many scores in the Northeast. During recent decades, the average number in the United States is about 200 per year; the death toll often rises to more than 300 people per year, and the property loss to many millions of dollars.

The whirling winds of some tornadoes attain velocities of more than 500 miles per hour. Destruction is also caused by the "explosions" of buildings passed over, because the air pressure at the center of the storm is low, "nearly a vacuum."

Almost unbelievable happenings occur in tornadoes, with many miraculous escapes. They are such small storms, having an average width of about 400 yards and a length of a few miles (damaging only an average of three square miles), that even where they are most frequent, they normally strike a given small area only rarely. Sometimes, however, a small area may be hit by a succession of tornadoes.

In the thirty-four years ending with 1949, the states with most tornadoes officially recorded are: Kansas, 587; Iowa, 512; Texas, 461; Oklahoma, 369; Arkansas, 299; and Mississippi, 207. States with 100–190 were Alabama, Nebraska, Minnesota, Illinois, Georgia, Florida, Louisiana, Indiana, South Dakota, South Carolina, Tennessee, Wisconsin, and Ohio.

The states having the greatest property damage from tornadoes during the thirty-four years ending with 1949, with the millions lost, are: Oklahoma, 52; Illinois, 48; Missouri, 44; Texas, 34; Georgia, 28; Ohio, 25; Indiana, 23; Kansas, 20; Iowa, 20; Minnesota, 18; Arkansas, 17; Alabama, 16; and Mississippi, 15.

The states with the most deaths caused by tornadoes in those thirty-four years are: Illinois, 911; Arkansas, 866; Mississippi, 792; Alabama, 714; Oklahoma, 664; Texas, 632; and Georgia, 527.

A person living for the normal life span, sixty-eight years, in Arkansas has one chance in 1529 of being killed by a tornado. In Oklahoma one's chances would be one in 1684, in Missouri one in 4132, and in Kansas one in 5736.

Among the subjects discussed by Flora are: When the Tornado Strikes, Cause and Structure, Destructive Force, Forecasts and Warnings, When to Expect Tornadoes, How to Escape Death and Protect Property, Freaks of the Storm, Some Outstanding Disasters, Tornado Hazard by States, Other Whirling Storms, and Tornadoes Elsewhere.

In brief, this book attains a high level of interest, reliability, and constructiveness. None of us in the United States is free from danger from tornadoes (which also occur very widely elsewhere). The effective presentation of facts about tornadoes and of methods found successful in reducing their destructiveness makes this book a contribution of which the author and the U. S. Weather Bureau can be proud.

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Early Man in America. A Study in Prehistory. E. H. Sellards. Austin: University of Texas Press, 1952. xvi + 211 pp. Illus. $4.50.

RAPIDLY accumulating information in the Americas on the association of artifacts and human bones with the bones of extinct animals or other evidence of comparable antiquity poses a difficult problem for those who wish to acquire or maintain familiarity with the data of the field. Dr. Sellards' book is a valuable and timely compendium of the subject which will be highly useful to students of American archaeology.

ALBERT C. SPAULDING

Museum of Anthropology,
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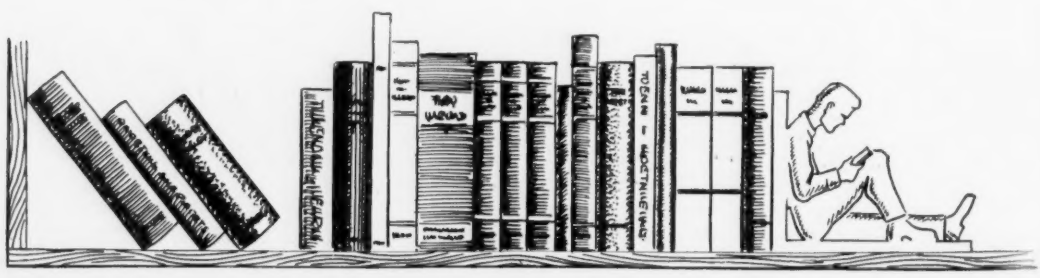

ASSOCIATION AFFAIRS

PRELIMINARY ANNOUNCEMENT, SEVENTH BOSTON MEETING DECEMBER 26–31, 1953

FROM the programs and other events already arranged, it is apparent that the 120th Meeting of the AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will be particularly well balanced, well attended, and significant—one of the best meetings in the long annals of the Association. At this time the Association, soon to enter its 106th year, with 238 affiliates and 50,000 individual members, is on the threshold of careful studies to see how its services to science, to scientific organizations, to scientists, and to society may be improved and increased.

One of the fundamental purposes for which the Association was founded, in September, 1848, still endures: "... by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States. . . ." At Boston this December the annual meeting for the year 1953 once more will bring together leaders and younger men and women in the principal fields of science, not only to read papers reporting current research and to discuss their specialties, but also to attend outstanding symposia and to consider some of the problems that affect science and the world today. This 120th Meeting has as its theme "Scientific Resources for Freedom," and a number of the 18 sections of the Association and participating societies will have programs devoted to physical resources, scientific manpower, and scientific techniques—men, materials, and methods—related to the national economy, security, and welfare.

Although this year's 120th Meeting is typical of AAAS meetings in the past—with national meetings of large societies, interdisciplinary sectional symposia, sessions for contributed papers arranged by many of the sections, distinguished evening addresses, a large-scale Exposition of Science and Industry, and a showing of the latest foreign and domestic scientific films—there is a growing trend toward recurrent conferences in which many scientists, irrespective of their specialties, will be interested. At Boston, in addition to the Academy Conference representing the 40 academies of science now affiliated with the Association, the Conference on Scientific Editorial Problems II, and the Conference on Scientific Manpower III, there will be one or two sessions on "The Scientist in American Society" and two sessions on "Transmission of Ideas." For the first time in many years, a past president of the British Association for the Advancement of Science, Dr. A. V. Hill, will be present and will address the American Association.

AAAS general symposia. The Association will sponsor two general symposia, each of two sessions, in accordance with the decisions of the 1953 Symposium Committee consisting of E. U. Condon, chairman; Frank A. Beach; Bart J. Bok; Charles D. Coryell; A. M. Gaudin; A. Baird Hastings; Jerome C. Hunsaker; James R. Killian, Jr.; Paul C. Mangelsdorf; Philip M. Morse; Alfred C. Redfield; Francis O. Schmitt; Earl P. Stevenson; George B. Wislocki; and Raymond L. Taylor, secretary.

On December 27, the general symposium, "Species Which Feed Mankind," suggested and planned by Paul C. Mangelsdorf, will deal with the scientific aspects of several of the critical species of plants and animals that comprise the basic food sources of man. Although the symposium will stress the most recent findings in genetics, plant pathology, and animal husbandry, it is important for all.

On December 29, the second general symposium, "The Sea Frontier," with Alfred C. Redfield and Jerome C. Hunsaker as co-chairman, will bring together a number of the phenomena of the interface of land and salt water. Aspects included will be the geology of beaches, littoral oceanography, marine ecology, and interrelated engineering and industrial problems.

Focus of the meeting. The activities of the meeting period will center in downtown Boston in the Mechanics Building at 111 Huntington Avenue. Here will be located the Main Registration and Information Center (the only source for special booklets on Boston's points of interest and other literature), the Visible Directory of Registrants, the AAAS Office, the AAAS Science Theatre, and the Annual Exposition of Science and Industry. In the meeting rooms of the building will be held the general symposia and principal sectional programs and, from 8:30 to 11:30 P.M., December 29, the Biologists' Smoker. In nearby Copley Square, the geneticists will occupy the Sheraton Plaza Hotel, and other sessions will utilize auditoria in the Boston Public Library and in Boston University Junior College. Three blocks east of Copley Square, the zoological societies will be based at the Statler Hotel, and two blocks farther, the three science teaching societies will meet in the Hotel Bradford. In Horticultural Hall, three blocks in the opposite direction from Mechanics Building, there will be other sessions. Between the extremes in each direction, the distance is little more than one mile. In general, no one will be more than 5 to 10 minutes away from any other meeting point. Underground trolleys along Huntington Avenue and Boylston Street, with subway connections, will be convenient for those who wish to visit demonstrations or open houses at MIT and Harvard University.

Hotels. The Statler Hotel will be AAAS Headquarters and the locale of such evening events as the Association's Presidential Address, by Detlev W. Bronk, and the AAAS Reception on December 28, and also the

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annual addresses of the Scientific Research Society of America, the Society of the Sigma Xi, and the United Chapters of Phi Beta Kappa, the dates of which will be announced. Sessions will be held in the Statler (zoologists), the Sheraton Plaza (geneticists), and in the Bradford Hotel (science teachers). Other hotels, to be used primarily for sleeping accommodations, are: the Touraine and Parker House in downtown Boston; the Copley Square, Lenox, and Vendome, near Mechanics Hall; and the Somerset and Kenmore on Commonwealth Avenue in the Back Bay area. Headquarters of each participating society will be given in a later announcement. Detailed housing information and a coupon for room reservations will appear in SCIENCE and THE SCIENTIFIC MONTHLY beginning about the end of July.

Advance registration. As in recent years, advance registrants will receive the General Program-Directory early in December by first-class mail. Coupons will appear in the AAAS journals beginning in late July.

THE PROGRAMS

A—Mathematics

Section A will schedule a vice-presidential address.

B—Physics

Section B will have two symposia; in addition, it will cosponsor with Section M "Transformations within Metallic Crystals" arranged by A. M. Gaudin, and the symposium of Section D; the retiring vice-presidential address, on a subject relating to the upper atmosphere, will be given by O. E. Hulburt. The *American Meteorological Society* will hold a national meeting with two or more sessions for papers.

C—Chemistry

Section C, with Randolph T. Major as program chairman, will have several sessions for contributed papers, principally on Dec. 27, and a six-session symposium, "Feeding the Nation": I and II—Human and Animal Nutrition arranged by Robert S. Harris; III—Chemicals in Food, by Charles N. Frey; IV—Chemistry of the Sea as Related to Food Problems, by Harold J. Humm; V—Growth and Nutrition of Plants, by P. W. Zimmerman; VI—Recent Progress in Food Processing, by B. E. Proctor. Appropriate parts will be cosponsored by Sections Nm, G, and O. Dr. Major will give the vice-presidential address. *Alpha Chi Sigma* will schedule a Chemists' Luncheon.

D—Astronomy

Section D will have a comprehensive symposium and panel discussion on "Current Progress in Radio Astronomy" arranged by Bart J. Bok, and a vice-presidential address, "Identifications of Solar Lines," by Charlotte Moore Sitterly, the morning, afternoon, and evening of Dec. 26, in the Lecture Hall of the American Academy of Arts and Sciences.

E—Geology and Geography

Section E is scheduling a two-session symposium in geology and two one-session symposia in geography concurrently on Dec. 28; a two-session symposium, "Water for Industry," on Dec. 29; and concurrent sessions for contributed papers in geology and geography, Dec. 30 and 31, with appropriate parts of the week's program cosponsored by the *Geological Society of America* and the New England Division, *Association of American Geographers*. The Geologists' Smoker and vice-presidential address by Arthur C. Trowbridge will be the evening of Dec. 30. The *National Speleological Society* will meet the afternoon of Dec. 26.

F—Zoological Sciences

The *American Society of Zoologists* will open four days of sessions Dec. 27 with a symposium, have four concurrent sessions the mornings and afternoons of Dec. 28 and 29, and a second symposium and demonstrations at Harvard on Dec. 30. The Zoologists' Dinner will be on the evening of Dec. 29; an illustrated address will be given by Paul Weiss, vice president of Section F, which will cosponsor the American Society of Zoologists symposia. The *Herpetologists' League* will meet the afternoon of Dec. 28. The recently incorporated *Massachusetts Zoological Society* will have sessions for papers. The *Society of Systematic Zoology* will open four days of meetings with a symposium the evening of Dec. 27, hold sessions for papers, and business meetings the other days.

FG—Zoological and Botanical Sciences

Among the societies whose fields lie in both botany and zoology, the *American Society of Naturalists* this year will hold its annual meeting with the Association with a business session, a symposium, and a presidential address. *Beta Beta Beta* will hold its biennial convention, with an address by Edmund W. Sinnott, executive sessions on Dec. 28 and a luncheon and afternoon session on Dec. 29. The *American Society of Human Genetics* has scheduled three morning sessions for papers, Dec. 28–30; a business meeting, Dec. 28; three afternoon symposia: "Human Genetics and Medical Education," Dec. 28, "Genetic Factors Affecting Intelligence," jointly with the *American Eugenics Society*, Dec. 29, and "Genetics and the Races of Man," cosponsored by the Genetics Society of America, Dec. 30. The annual dinner and presidential address of the society, by C. P. Oliver, will be the evening of Dec. 29 at the Copley Square Hotel. The sessions of the annual meeting of the *Genetics Society of America* include meetings of the Executive Committee, Dec. 27 and 30; concurrent sessions for papers Dec. 28–30; a luncheon, business meeting, and demonstrations the afternoon of Dec. 29; and the joint symposium, "Genetics and the Races of Man," with the American Society of Human Genetics. The *Ecological Society of America* will cosponsor appropriate sessions of Section G and of the American Society of Zoologists and may have a program of its own. The *Society for the Study of Evolution* will have a program at Boston, arranged by Alfred Romer, and it is expected that the *Society for Industrial Microbiology* will again have several days of sessions with the AAAS. The *National Association of Biology Teachers* will hold its annual meeting Dec. 27–31 with the Association.

G—Botanical Sciences

Section G will have sessions for contributed papers, a number of symposia—including one of two sessions on "Native American Crop Plants and Climatic History in Relation to Man," arranged by Volney Jones and cosponsored by Section H, and one on plant physiology cosponsored by the New England Section of the *American Society of Plant Physiologists*—and a Botanists' Dinner at which Edgar Anderson will give the vice-presidential address.

H—Anthropology

Section H will have a two-session symposium on "Non-Human Primates and Human Evolution" arranged by James A. Gavan, Dec. 27; a symposium on "Theoretical Models for the Study of Cultural Process and Change" by Evon Z. Vogt; the joint symposium with Section G; a group of invited papers on "New England Archaeology" arranged by Douglas Byers, Dec. 29; and sessions for contributed papers, Dec. 29, in the fields of archaeology, social anthropology, etc. The Anthropologists' Dinner and vice-presidential address by Clyde Kluckhohn will be on the evening of Dec. 27.

I—Psychology

The program of Section I includes sessions for invited papers in the areas of learning, comparative behavior, brain function, human engineering, and sensory processes—arranged, respectively, by Fred D. Sheffield, Burton S. Rosner, Walter A. Rosenblith, Leonard C. Mead, and Edwin B. Newman—and for contributed papers, over the period Dec. 28–30. The vice-presidential address will be given on the evening of Dec. 30 by Frank A. Beach.

K—Social and Economic Sciences

Section K has planned two or three two-session symposia, including "Economic Problems of New England," Dec. 27, and "Effects of War on Scientific Development," Dec. 29. The *National Academy of Economics and Political Science* will have a symposium cosponsored by Section K and in collaboration with *Pi Gamma Mu*.

L—History and Philosophy of Science

The program of Section L includes a joint symposium, "Art and Science," with the Philosophy of Science Association, on the afternoon of Dec. 27; on Dec. 28 a symposium, on "Criteria for Validity in Science" arranged by Philipp G. Frank, cosponsored by the *Institute for the Unity of Science;* and a joint symposium, "Science and General Education," with Section Q and the History of Science Society. The *History of Science Society,* holding its annual meeting with the AAAS, will have a day or two of contributed papers and other events and will cosponsor appropriate symposia of Section L. The *Philosophy of Science Association* will arrange a program for Dec. 30 and cosponsor the symposia of Section L.

M—Engineering

Section M will have a series of symposia: "Aids to the Blind" arranged by Eugene F. Murphy, cosponsored by Sections N and I; "Safety as a Natural Resource"; "The Boston Banks and the Growth Potential of New England" cosponsored by Section P; and the one on metallic crystals referred to under Section B.

N—Medical Sciences

Alpha Epsilon Delta National Premedical Honor Society will hold its annual luncheon Dec. 29. The *American Physiological Society* again will have a symposium under the auspices of the Survey of Physiological Science. The *American Association of Hospital Consultants* will sponsor a symposium on "The Research Function of the Hospital" arranged by E. M. Bluestone; speakers include Jack Masur, Dean A. Clark, and Harvey Agnew, and discussants.

Subsection Nm—Medicine

Subsection Nm will sponsor a four-session symposium "Antimetabolites and Cancer" arranged by Cornelius P. Rhoads and Allan D. Bass, Dec. 28 and 29. The vice-presidential address will be given by Dr. Rhoads.

Subsection Nd—Dentistry

Subsection Nd plans three sessions on Dec. 29 arranged by Howard R. Marjerison.

Subsection Np—Pharmacy

Over the period Dec. 26–31, Subsection Np will have sessions for contributed papers and symposia cosponsored by the Scientific Section of the *American Pharmaceutical Association,* the *American Society of Hospital Pharmacists,* the *American Association of Colleges of Pharmacy,* the *American College of Apothecaries,* the *American Drug Manufacturers' Association,* and the *American Pharmaceutical Manufacturers' Association.*

O—Agriculture

Section O plans some four sessions for Dec. 28 and 29.

P—Industrial Science

Section P, now in its third year, will have a program arranged by Francis J. Curtis. The New England Section of the *American Industrial Hygiene Association* will have a two-day program arranged by W. M. Pierce, consisting of joint meetings with other groups on Dec. 28, a technical session of the society the morning of Dec. 29, and papers of general interest on industrial hygiene, on the afternoon of Dec. 29. (Those interested in giving papers should communicate with F. J. Viles, Jr., Department of Industrial Medicine, MIT.) The *Society for Industrial Microbiology,* it is expected, will have sessions for contributed papers and a symposium, as in prior years.

Q—Education

Section Q plans a two-session symposium on "Visual Efficiency in Industry" and another of three sessions on "Conserving Human Resources," sessions for contributed papers, and a vice-presidential address by Donald D. Durrell, Dec. 28–30. The *AAAS Cooperative Committee on the Teaching of Science and Mathematics* will have a two-session symposium, arranged by George G. Mallinson and cosponsored by Section Q and the three science teaching societies, Dec. 27. The *National Science Teachers Association* will have three days of sessions, a number of them concurrent, others joint with the National Association of Biology Teachers and the American Nature Study Society, Dec. 28–30. The *American Nature Study Society's* annual meeting, from Dec. 26–30, includes a program on marine biology, two sessions on animal ecology, sessions and presidential address, and a field trip with the National Association of Biology Teachers.

X—Science in General

The *Committee on Disaster Studies, National Research Council* is sponsoring the symposium "Disaster Recovery II," arranged by Harry Williams. The *National Association of Sciences Writers* will hold its annual meeting with the AAAS and have a program. The *Scientific Research Society* and the *Society of the Sigma Xi* will sponsor evenings addresses and, on Dec. 29, hold their annual conventions with the Association. The *National Geographic Society* and the *United Chapters of Phi Beta Kappa* will arrange evening addresses.

Call for Papers by AAAS Sections

The following sections of the Association will have sessions for contributed papers. The secretaries or pro-

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gram chairmen to whom titles and brief abstracts should be sent, *not later than September 30, 1953,* follow:

C—Chemistry Dr. Ed. F. Degering, George Washington Inn, New Jersey and C Streets, S.E. Washington, D. C.

E—Geology and Geography Dr. Jack B. Graham, 3400 North Westmoreland Street, Falls Church, Va.

G—Botanical Sciences Dr. Stanley A. Cain, School of Natural Resources, University of Michigan, Ann Arbor, Mich.

H—Anthropology Dr. Gabriel Lasker, Wayne University, 1512 St. Antoine Street, Detroit 26, Mich.

I—Psychology Dr. William D. Neff, Department of Psychology, University of Chicago, Chicago 37, Ill.

Nd—Dentistry Dr. Russell W. Bunting, School of Dentistry, University of Michigan, Ann Arbor, Mich.

Np—Pharmacy George F. Archambault, Pharmacy Branch, Division of Hospitals, Federal Security Agency, Public Health Service, Washington 25, D. C.

O—Agriculture Dr. C. E. Millar, Department of Soil Science, Michigan State College, East Lansing, Mich.

Q—Education Dr. D. A. Worcester, University of Nebraska, Lincoln, Nebraska.

RAYMOND L. TAYLOR
Associate Administrative Secretary

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE is an organization that has roughly fifty thousand individual members, and that represents affiliations with nearly two hundred scientific societies and academies. The Association has great potentialities for service to individual scientists, scientific groups, to science in general, and to our modern democratic society. It is the deep wish and the firm intention of the officers of the Association to do all in their power to help realize these potentialities.

To move forward with constructive and wise developments will require the best thinking of all the membership—hard and serious thinking, objective and loyal thinking. It will require imagination and the courage to run some risks in the attempt to serve great ends. We are confident that these qualities will be available to serve our Association.

In a situation such as ours, there is always danger that some members fear that changes will be too abrupt and too revolutionary, while many others are disappointed because there seems to be no progress. We ask for both confidence and patience. To the members of the first group we want to say that there is not, and never has been, so far as we know, any desire to bring about change that would be disruptive either in tempo or character. To the members of the second group we want to say that progress toward the Arden House goals is necessarily and properly slow; even though that progress has not become evident as yet, or in any event has not been publicly acclaimed, it is occurring.

Although it is the expressed will of the Association, as evidenced by the unanimous vote of the Council in favor of the Arden House policy, to alter, to modernize, and to enliven the annual meetings of the AAAS, we wish to caution that these changes should be worked out sensibly and gradually, proceeding by trial so that it can be assured that the meetings do in fact furnish that sort of inspiring contact with all of science which, we are sure, is desired by the membership.

In particular it is clear that for the time being it is important to include, at the big annual meeting, a certain body of short reports of current research in specialized fields. We bespeak, for our Association and, particularly, for the meeting in Boston this next winter, a full and active participation. We pledge that we will do our utmost to see to it that the Association, in all branches of its work, deserves your active support.

DETLEV W. BRONK, *Retiring President*
E. U. CONDON, *President*
WARREN WEAVER, *President-Elect*